Ethnobotanical focus on the traditional uses of plants in the Ziz Valley, Errachidia, in the Biosphere Reserve of the Oases of Southwestern Morocco by local populations

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Research

Abstract

Background: Ziz Valley, part of the Southern Moroccan Biosphere Reserve, is a rich arid ecosystem that is ideal for a study of plant diversity that has adapted to extreme climate conditions.

Objective: Our study aims to record the diversity of plant taxa used by the local Arabic and Amazigh-speaking communities of the Ziz Valley, Errachidia, Morocco, in the province of Errachidia. The research aims to describe traditional knowledge related to medicinal, food, cosmetic and forage use.

Methods: To achieve this goal, a survey was carried out throughout the Study area, recording various plant taxa used and their distribution in botanical families. Quantitative ethnobotanical indices (UV, RFC, FUV) are used to describe traditional use in medicinal, food, cosmetic and other uses. Moreover, it explores how this generational knowledge is transferred and encoded in ethnos, as well as the risk of traditional knowledge loss caused by modernization and rural migration

Results: 148 plant taxa from 52 families, mostly from the Lamiaceae, were listed, with 761 references. The majority of the plants are wild (56.5 % or cultivated (37.3 %). The use for medicinal purposes is the most prevalent (61.4 %), mostly for digestive, nervous and dermatological diseases. Then, culinary use (24.6 %). The parts harvested are the leaves, fruits and seeds. This is the traditional knowledge that has been documented by the local ethnotaxonomic system and has been passed on primarily through family and tribal structures. Regarding safety, 73% of informants reported no adverse effects and 9 % frequent incidents.

Conclusion: Urgent documentation and conservation of traditional knowledge and endemic species in this ecosystem are imperative.

*Keywords***:** Ziz Valley, ethnobotanical survey, plant uses, traditional medicine, Ethnotaxonomy.

Background

Morocco is a veritable hotspot of biodiversity, with vascular flora that, based on a recent inventory, comprises 155 families, 981 genera, and 3,913 species (3,913 indigenous, including 64 Pteridophyta, 17 Pinophyta, 699 Monocotyledonae, and 3,133 Dicotyledonae), 426 type subspecies (autonyms) and 872 additional subspecies. The complete flora is richer with the addition of 261 species of doubtful presence, 54 hybrids, 67 adventitious species, 74 naturalised species and 76 species with uncertain status (adventitious or naturalised) (Fennane 2012). The number of strictly endemic species is 640, or 16.3% of the national inventory. The uniqueness of Morocco's vascular flora is also marked by the presence of 14 endemic genera. This rate of endemism represents more than half of the endemic flora of North Africa and about 19% of the vascular plant diversity of the continent (Catullo 2011).

This remarkable richness is largely attributed to the country's diverse environments, the oases of southern Morocco, encompassed within the Reserve of the Biosphere of the Oases of Southern Morocco (RBOSM) (Houssni 2023) exemplify this diversity, with nearly 370 plant taxa recorded, including 84 threatened plant taxa, 44 rare plant taxa, and 19 endemics, these oases also have a significant part in the preservation of genetic diversity, especially of date palms, in which 453 genotypes of date palm were recorded and a wide variety of local livestock breed (El Bakouri 2025).

The sparse vegetation of desert ecosystems in Morocco, which is mainly made up of regs (rocky plains) and ergs (sandy dunes) is characterized by low density vegetation that is dominated by acacia taxa, these arid ecosystems, which are receiving very low annual precipitation rates, usually less than 50 mm, still provide a remarkably rich biodiversity, with over 730 taxa of flora identified, 60 of which are endemic The Rissani oasis which forms one of the main parts of our study area was already reported to be ethnobotanical rich. In this locality, El Mansouri also found a large number of medicinal plants that are very important, with high socioeconomic value, because plant resources play a central role in the livelihoods of the oasis people (El Mansouri 2011).

The Ziz Valley (Errachidia province) is part of the RBOSM that was listed by UNESCO in 2000 (Karmaoui 2023, Houssni 2018, Bouaouinate 2015). The reserve covers the territories of the main oases on the southern slope of the High Atlas, the catchment areas of the rivers Draa, Ziz, and Guriss. The RBOSM aims to reconcile biodiversity conservation and cultural heritage preservation, and to support the sustainable development of oasis populations. It protects fragile ecosystems characterised by an arid climate and adapted vegetation, notably the traditional palm groves, which constitute a unique ecological and cultural heritage.

Endemism can be observed at multiple levels of the biogeographical region: strictly Moroccan endemism, Maghreb endemism, and Saharan endemism, due to the intermediate location of this place between the High Atlas and the Sahara. Among the 148 listed, 56.5% have been described as spontaneous, with icons such as *Warionia saharae* Benth. & Coss. (Asteraceae), a strictly Saharan endemic and only known in the hyper-arid areas of Morocco and Algeria, Pistacia atlantica (Anacardiaceae), a North African endemic species adapted to limestone substrates, and *Atractylis gummifera*, a Mediterranean-Saharan species, typical of degraded steppes (Msanda 2021). The restrictive ecological factors, such as water stress, temperatures surpassing 35° C and skeletal soils, which impose a selective pressure that skews towards speciation and retention of relict lineages since the Pleistocene, are what make endemism in this region possible. Maintaining this endemism is also a significant conservation issue, as such species, which are frequently poorly dispersed and limited in range, are especially susceptible to climate change and the growing anthropisation of oases (Medail 1997).

Plants have long served as sources of medicine and aromatic remedies across human civilisations. Even with advances in modern pharmacology (Ajebli 2019), traditional plant use remains central to therapeutic practices, especially in developing.

Moroccan oases harbour rich biocultural heritage, yet the Ziz Valley's ethnobotanical knowledge remains underdocumented compared to the High Atlas or Rif. Prior Errachidia studies focused narrowly on medicinal uses or limited species, lacking comprehensive multi-use quantitative analyses. This gap is critical given escalating pressures from overharvesting, aridification, habitat loss, rural exodus, and vanishing elder experts on this UNESCO Biosphere Reserve, demanding urgent systematic documentation before irreversible knowledge loss occurs.

The main objective of this study is to document and classify the plant diversity of the Ziz Valley through an ethnobotanical approach that incorporates local traditional knowledge. This knowledge supports sustainable management of natural resources and the conservation of oasis ecosystems.

Materials and Methods

Study area

Geographic location

Since 2000, UNESCO designated the Biosphere Reserve of the Oases (RBOSM) (UNESCO 2000), covering about eighty thousand square kilometres. This area integrates the areas of the rivers Deraa, Guir and Ziz, and a great part of the Oases of southern Morocco. RBSOM aims to promote conservation of biodiversity and cultural heritage and the sustainable development of the local population. It also aims to conserve the fragile ecosystem in this arid area (Mirari 2018).

Geographically, Errachidia province, an important part of RBSOM, is bordered by: Midelt province to the north; Figuig province to the northeast; Algeria to the south and southeast; Tinghir and Zagora provinces to the west. It is composed of five administrative circles: Errachidia, Rissani, Erfoud, Tinjdad, and Goulmima (Karmaoui 2023, Salem 2024). Located in Morocco's pre-Saharan zone, the Errachidia province was chosen for study due to its ecological significance and the UNESCO biosphere reserve status of its oases since 2000. While agriculture sustains the socio-economic well-being of a large population, this heavy reliance makes the society highly vulnerable to changes in water resources. As a result, people's livelihoods are closely linked to climate conditions, a challenge common to most oases worldwide (Karmaoui 2023).

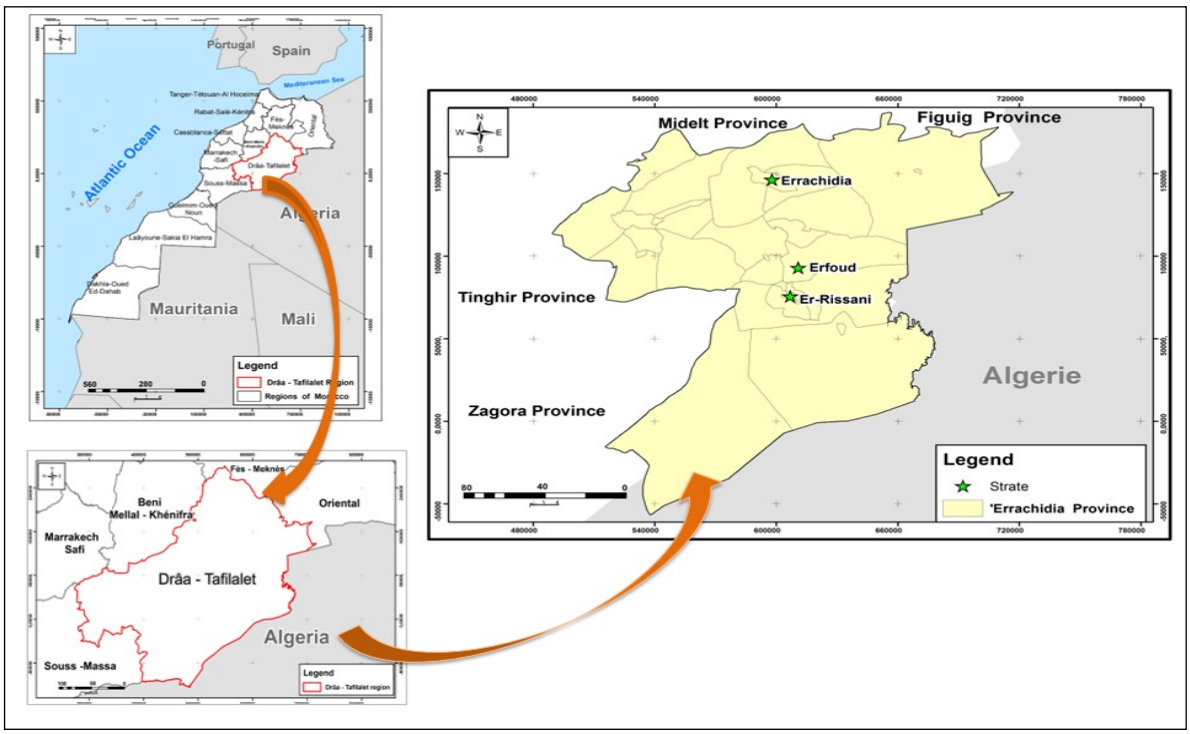

Figure 1. Administrative map of the studied circles, modified (Plan 2019), with ArcGIS 10.8

According to the last General Census of Inhabitants 2024, the population of Errachidia Province is about 423,055 (50.91 % women; 49.08% men) (Maaroufi 2024). This population is generally young; ages between 15 and 49 represent 57.4%, while

those aged up 60 represent 12.8%. The Errachidia population is bilingual, with 64.6% being Arabophones and 35.4% being Amazighophones. Amazigh people speak an Afro-Asiatic language (Karmaoui 2023).

The territory of Errachidia is structured into four major morphological units: The High Atlas (North): A mountainous area dominated by Jurassic and Cretaceous limestone formations, inhabited by approximately 5.5% of the population. The Hamadas: Vast sedimentary plateaus that cover nearly 37% of the province, dissected by wadis such as the Ziz, Guir, and Gaheris, and supporting about 36.3% of the population. The Tafilalet Plain: A broad depression between the Anti-Atlas and the Hamadas, extending over 49% of the territory and accommodating nearly 58.2% of the inhabitants. The Eastern Anti-Atlas: Composed primarily of Palaeozoic rocks, including schist, sandstone, limestone, and volcanic formations, and encompassing several rural communes (Plan 2019). The arid climate and scarce vegetation cover strongly shape the soil types in this province; as a result, most soils remain poorly developed, while well-structured soils are relatively rare. Such occurrences generally result from particular local conditions or from ancient soil layers (paleosols), which are often identified in date palm plantations. In these groves, higher moisture availability favours the development of soils with differentiated horizons, making them more suitable for cultivation. Nevertheless, soils with good agricultural potential are generally fragile, highly susceptible to water runoff, wind erosion, and salinisation.

Climate and hydrology

The province of Errachidia, including the Ziz Valley, has a harsh, arid-to-semi-Saharan climate with marked temperature differences and scarce rainfall. Average annual temperatures range from 20 to 22 °C, with winter lows around 10 °C and summer highs often above 35 °C, reaching up to 45 °C during heat waves. Rainfall is very low, about 50-120 mm yearly, mostly from November to March, while summers are nearly dry and droughts are common due to climate change (Ben Salem & El Alami El Filali 2024).

Our study area is known for its high evapotranspiration, 2000mm/year, and low humidity generally under 40%; Sirocco and Chergui are hot and dry winds blowing over Rissani and Erfoud, reduces visibility and damaging agriculture (Ait Lamqadem 2018) Emberger classes this region as predominantly arid with milder winters in the Tafilalet basin, and near High Atlas foothills, we face cooler semi-arid conditions, which influence vegetation and favour xerophytic and halophytic vegetation (Mokhtari 2014)

Water sources in the Ziz Basin include seasonal wadis, groundwater, and the Hassan Addakhil Dam, supplying irrigation and domestic needs. Traditional khettaras and springs remain essential, reflecting sustainable oasis water management. However, overuse, salinity, and less rainfall threaten water availability, endangering farming and biodiversity (Lightfoot 1996).

Data collection

To document the uses and characteristics of medicinal plants in Ziz Valley, part of the Tafilalet Biosphere Reserve of the Oases of Southern Morocco, our ethnobotanical survey was carried out from July 2024 to January 2025 in the three circles crossed by the Ziz River, covering the main areas of the reserve, including locations in the province such as the cities of Errachidia, Rissani, and Erfoud.

The questionnaire that we used was developed based on previous studies (Martin 2006, De Meyer 2022, Albuquerque 2019, Khabbach 2012, Ghabbour 2024) to collect the necessary information for this study. It was designed and administered to the surveyed population living or having lived in the study area. The questionnaire consisted of closed and semi-closed questions, and two complementary approaches were used for its administration: questionnaire sheets and note-taking during face-to-face interviews. Oral interviews were conducted in person, during which the interviewer completed the questionnaire based on the participants' responses. Fig. 2. All collected data were recorded on dedicated forms to allow for a thorough analysis at the end of the study. In parallel, online data collection was carried out via Google Forms, shared on social networks, particularly WhatsApp. The standardised questionnaire included detailed questions about the informants, the local nomenclature of the plants used, medicinal and/or edible plants, as well as various demographic variables (age, gender, etc.). The survey also addressed ethnobotanical aspects, such as plant parts used and modes of utilisation, as well as ethnopharmacological aspects, including preparation techniques and methods of administration.

Sampling followed a non-probabilistic, purposive and snowball approach, targeting key informants (herbalists, healers, farmers, housewives) known for their ethnobotanical knowledge. A pilot test of the questionnaire was conducted with 15 informants in Rissani to refine question phrasing and local terminology before full administration. Nomadic populations and youth under 20 were underrepresented due to limited accessibility and mobility, which constitutes a limitation of this study.

Before data collection, participants were fully informed of the study's scientific and academic objectives and the importance of their participation. Their informed consent was obtained, and they were made aware of their right to refuse to answer or withdraw their responses at any time. A total of 220 individuals participated in the study.

Every use was collected individually, and a single plant can have many applications; thus, the calculated percentage based on the total number of use data may not reach 100%**.**

Herbalist in Merzouga, Rissani

Herberistry in Merzouga,Rissani

Interviewing an old man in Rissani local market

Interviewing a rural man at the Rissani weekly market

Interviewing a woman in Errachidia

Man preparing tea with equipment made from the acacia gum plant.

Figure 2. Some photographs from ethnobotanical interviews with local herbalists and residents of the study area

Ethical considerations

The study was done in accordance with the principles of the Nagoya Protocol and the International Society of Ethnobiology CoE of Ethics. All the participants were given their free, prior, informed consent (FPIC) orally after being informed about the

goals of the study in their own language (Moroccan Arabic/Tamazight). Confidentiality and anonymity of the informants were highly preserved. Traditional knowledge is the intellectual right of local communities, and research will be made available to the participants to help them conserve traditionally (Biosafety 2011).

Simultaneously with the ethnobotanical survey, an ethotaxonomic survey was done in a systematic manner. Inventories were made of the vernacular names of each taxon catalogued in both Arabic dialect (Darija) and Amazigh (Tamazight), as spoken by the Arabic- and Amazigh-speaking communities of the Ziz Valley. The obtained forms were phonetically transcribed using a standardised Arabic-Latin transliteration system and analysed against the list of names provided by Brahim Iaazza (Brahim 2019) to assess their consistency and local variations. Qualitative and comparative analysis was then applied to all the ethnotaxonomic data with a view to defining the prevailing nomenclatural logics. It was possible to investigate the degree to which vernacular classifications mirror the ecological understanding, cultural allusions, and customary applications of the plants in this oasis biocultural setting through this approach.

Table 1. Transliteration characters used in the survey

Symbol	Arabic Letter	Symbol	Arabic Letter	Symbol	Arabic Letter	Symbol	Arabic Letter
A	ا	F	ف	L	ل	T	ت - ة
Â	ع	G	ق - گ	N	ن	ṭ	ط
ā (1)	ا - ي - آ	Ġ	غ	O	و	ṯ	ث
Å	ني - و	H	ه - ة	ô (1)	و	ū (1)	و
B	ب	ḥ	ح	P	ب	u (2)	و
D	د	ḫ	خ	Q	ق	V	ف
ḍ	ذ	I	ي	R	ر	w (2)	و
ḏ	ض	ī (1)	ي	S	س	y (2)	ي
E	و	J	ج	Š	ش	Z	ز
ē (1)	و	K	ك - ق	ṣ	ص	ẓ	ظ

Plant determination

During the study period, specimens were collected and identified based on available flora, and scientific nomenclature was updated, referring to the following databases: FLORE PRATIQUE DU MAROC (FENNANE 2014), the World Flora Online (CBD 2026) and the African Plant Database (South African National Biodiversity Institute 2026). Codes were assigned to each specimen, as shown in Table 2, and archived at the herbarium of Sidi Mohammed Ben Abdellah University.

Data analysis

All data resulting from the interviews were analysed using a quantitative approach, combining the Use Value (UV), the Relative Frequency of Citation (RFC) and the Family Use Value (FUV). The Use Value for each plant taxon was calculated as given above (El Kourchi 2024, Eddouks 2017, Hoffman 2007, El Aboui 2025, El-Assri 2021):

$$\mathrm{UV} = \sum \mathrm{Ui}/\mathrm{N}$$

In this formula, U signifies the number of respondents mentioning the species' use, while N indicates the total sample size.

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}}$$

Where FC is the number of informants who cited a given plant taxon, and N is the total number of informants interviewed

$$\mathrm{FUV} = \sum \mathrm{UVs}/\mathrm{Ns}$$

Where the UV_s of each species within a given family are compared to the total number recorded in that family.

Results and Discussion

Sociodemographic characteristics of the surveyed population

All these socio-demographic features are important for understanding the complexity and richness of ethnobotanical knowledge in the Ziz Valley. Most of the respondents were aged between 41 and 60 years (48.6%), highlighting this group's

contribution to the transmission of traditions. Rissani recorded the highest number of informants (40.9%), followed by Erfoud (33%) and Errachidia (26%). Most participants were rural residents (55.9%), compared to urban (37.3%) and nomadic (6.8%) residents. Educational attainment also varied, with secondary (31.5%), primary (27.5%), and illiterate (11.5%) levels being the most common.

These socio-demographic trends give a baseline understanding of how knowledge that is held by the traditional is organised and passed on to the people. The balance in gender distribution was not lost, but there is a difference in the form of ethnopharmacological knowledge between men and women. Women, especially housewives, are the primary guardians of herbal practices in the household, especially culinary, cosmetic, and dermatological, whereas men, who are usually the farmers or traders, are more conversant with forage, digestive and tonic plants. This division of knowledge based on gender emphasises the roles of complements in the preservation of traditional medicine (Adouane 2022). The dominance of middle-aged participants (41-60 years) underlines the importance of this group as cultural transmitters of ethnobotanical wisdom. In contrast, younger generations (under 40 years) displayed reduced engagement, reflecting a gradual erosion of traditional knowledge due to modernisation and shifting lifestyles (Bencheikh 2024, Amsalu 2025).

There are also geographical nuances that affect the sharing of knowledge. Rissani and Erfoud, where rural life is predominant in the area, use more wild herbs and self-medication, whereas those in Errachidia city are becoming more and more dependent on commercial herbal drugs. This tendency depicts the urban-rural gradient in the utilisation of plants, which is associated with access, environment, and cultural continuity (Abderrahman 2017). Moreover, ethnobotanical knowledge is also influenced by educational background. People who are educated to primary or secondary level (59%) were the most engaged in traditional practices, which indicates that moderate education supports the co-existence between traditional and modern healthcare systems. Conversely, better-educated people (21%) have stronger ties to modern medicine, whereas illiterate and Quranic school people (20%) stick to the oral traditions that are passed down by family and tribal ties, remarks that were also reported by Aboui (Aboui *et a*l. 2025).

To conclude, ethnopharmacological practices in the Ziz Valley are firmly rooted within the socio-demographic frameworks, as gender, education, and geography all influence the knowledge about the plants in the area. It is imperative to be aware of these interrelations in order to design sustainable approaches to maintaining and glorifying traditional medicinal heritage.

Table 2. Surveyed population sociodemographic profile

Characteristics	**Number of Informants**		**%**
Gendre	Men	120	54.54
	Women	100	45.46
Age	Under 20 years	8	3.64
	From 21 to 40 years	59	26.82
	From 41 to 60 years	107	48.64
	Up 60	46	20.91
Marital status	Married	138	62.73
	Single	21	9.55
	Other	61	27.73
Occupation	Housewife	70	31.82
	Official	44	20.00
	Farmer	36	16.36
	Merchant	30	13.64
	Daily worker	19	8.64
	Herbalist	4	1.82
	Student	4	1.82
	Other	12	5.45
Locality	Cercle of Rissani	90	40.91
	Cercle of Erfoud	73	33.18
	Cercle of Errachidia	57	25.91
Type de residence	Urban	83	37.73
	Rural	122	55.45
	Nomad	15	6.82

Academic level	High school	46	20.91
	Secondary school	68	30.91
	Primary school	61	27.73
	Coranic school	20	9.09
	Illiterate	25	11.36

Table 2 presents the sociodemographic information about the 220 informants. The sex ratio was nearly even, with 54.5% male and 45.5% female (total: 120 men and 100 women). Both groups were of similar size ($\chi^2 = 1.82$, df = 1, $p > 0.05$), and there was no difference between them regarding gender.1.2.

There was a significant difference in the distribution of age across categories ($\chi^2 = 91.00$, df = 3, $p < 0.001$). The 41-60 year age group was dominant (107 informants; 48.6%), followed by the 21-40 year group (59; 26.8%), informants aged over 60 years (46; 20.9%), and those under 20 years (8; 3.6%). Most of the middle-aged and older informants support the results obtained in other studies on the importance of traditional ethnobotanical knowledge holders who are also experienced people from the community (Eddouks *et al*. 2017; Bencheikh *et al*.2024).

The marital status was found to deviate significantly from the normal ($\chi^2 = 96.42$, df = 2, $p < 0.001$), with most informants being married (138; 62.7%), followed by the group "Other" (61; 27.7%) and the single informants (21; 9.5%). This distribution corresponds to the results of other Moroccan ethnobotanical studies (El Aboui *et al*. 2025), which reported that knowledge of traditional plants was mainly acquired in family groups.

To have informants from all over the study area, representatives were selected from the three administrative circles, Rissani (90; 40.9%), Erfoud (73; 33.2%) and Errachidia (57; 25.9%). The difference in the distribution of the localities was significant ($\chi^2 = 7.54$, df = 2, $p = 0.023$). The following distribution of informants by type of residence was significantly non-uniform ($\chi^2 = 79.48$, df = 2, $p < 0.001$): a majority were rural (122; 55.5%), then urban (83; 37.7%) and nomadic (15; 6.8%). This rural predominance is related to the nearness of oasis-based communities to plant-based health care systems, which is comparable with the results of El Mansouri's study in the Rissani oasis (El Mansouri *et al*. 2011).

Regarding occupational data ($\chi^2 = 143.10$, df = 7, $p < 0.001$), housewives constituted the largest group (70; 31.8%), followed by officials (44; 20.0%), farmers (36; 16.4%), merchants (30; 13.6%), daily workers (19; 8.6%), other occupations (12; 5.5%), herbalists (4; 1.8%), and students (4; 1.8%). The socio-economic structure of the study area is well represented with two categories: housewives and farmers, similar to the socio-economic structure represented in the other similar studies carried out in the southern part of Morocco (Adouan 2022).

There was a significant difference between categories in terms of educational level ($\chi^2 = 39.27$, df = 4, $p < 0.001$). The secondary school graduates came as the largest (68; 30.9%), followed by the primary school graduates (61; 27.7%), high school graduates (46; 20.9%), illiterate informants (25; 11.4%), and the smallest was Quranic school graduates (20; 9.1%). The total of no formal education and only Quranic education accounted for 20.5% of informants, while those receiving primary and secondary education accounted for 58.6% of the informants. This educational profile highlights the oral and experiential knowledge of ethnobotany recorded during this study, and reaffirms that traditional healing practices do not go away with moderate education levels (Tlemcani *et al*. 2023).

Transmission of ethnobotanical knowledge

Ethnobotanical knowledge is distributed mainly in the oral and community-based channels in the study area (Figure 3). The primary sources are parental heritage (44.91%) and tribal knowledge (42.27%), and secondary roles consist of traditional healers and herbalists (7.27%) and written or digital sources (5.55%). Modern sources are slowly appearing: Internet platforms are referred to by 8.5% of the respondents, and books or articles by 1.1%. Although they have low representation (0.6%), traditional healers are very important in legitimizing and transferring specialised knowledge. The low dependency on modern sources implies that there is a threat of knowledge loss because of globalisation, and that documentation strategies are much needed to preserve this intangible heritage.

The most used means of transmission is parental inheritance, which is closely followed by tribal knowledge. This is consistent with the results that showed the significance of family-based transmission in the Tafilaelt region of Morocco

This tendency is also advocated by more recent research in the Fes-Meknes area (El Aboui 2025, Kachmar 2021) and the necessity of elders to preserve ethnobotanical knowledge.

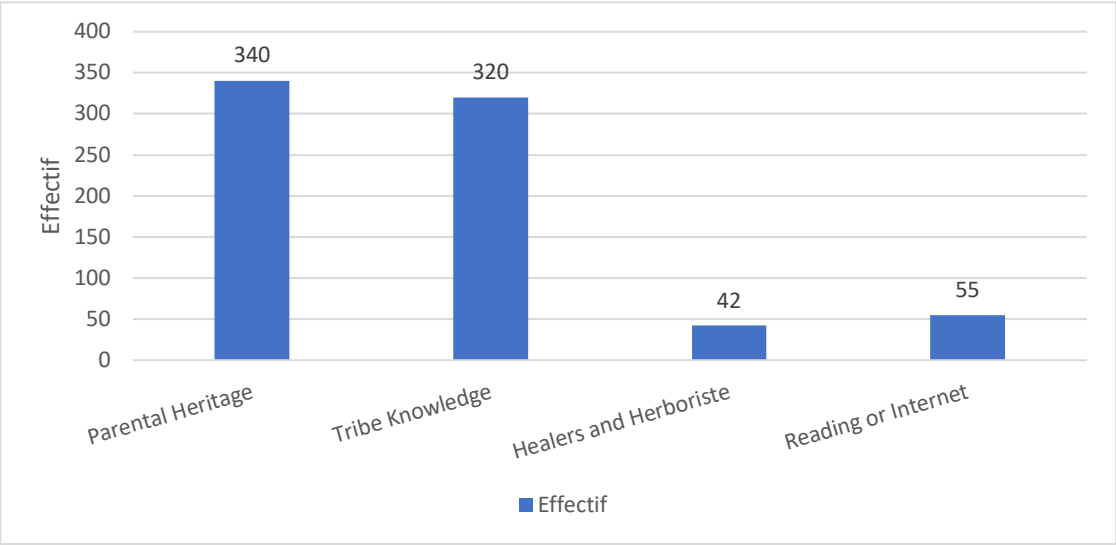

Figure 3. Transmission of ethnobotanical knowledge

This communication model (Fig 3bis) shows that ethnobotanical knowledge in Ziz Valley is mostly transmitted orally through kin networks (44.91%) and family networks (42.27%), whereas written and digital sources are the least (5.55%). The reduction in feedback towards younger generations indicates a decrease in inter-generational engagement as a result of modernisation and urbanisation. The lack of complementary documentation strategies makes the knowledge system's vulnerability visible: if it is passed on orally, without being documented, this intangible cultural heritage is vulnerable to being lost in just one or two generations.

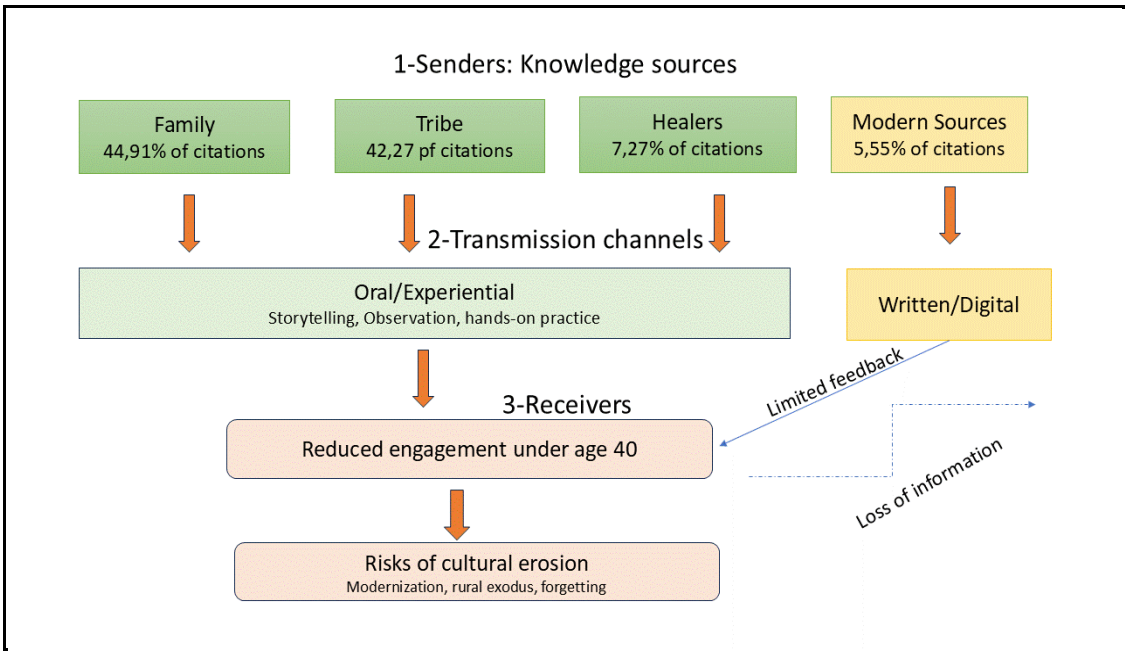

Figure 3bis. Communication model (sender-channel-receiver) of ethnobotanical knowledge transmission in the Ziz Valley

Systematic analysis of flora

The taxonomic distribution identified by the given survey indicates the prevalence of Lamiaceae (10.3%), which is expected considering other studies of the same topic (Jeddi 2021, Youssef 2025) where the mentioned family is dominant in the high altas in Erriche in the High Atlas. Whereas in the Rif in Mernissa, the dominant families are Asteraceae and Apiaceae;

accordingly, Kouider Djebel Aissa (Kouider 2019) reports the dominance of this family at 21.95%, while Tlemçani reports its dominance at 10.23% (Tlemcani 2023).

It is due to the abundance of active compounds in this family, to its climatic versatility, and economic utility that the convergence has its importance (Nieto 2017). Then followed Apiaceae (9.29) and Fabaceae (5.9%), which confirm further research examples of Benarba (Benarba 2015). Likewise, Poaceae (3.9%) indicates an important ecology of dominance and a key role in therapeutic tradition, 5.9% (Bellakhdar 1997).

Amazigh, Arab, and nomadic communities reside in the Ziz Valley and have a long tradition of using plants, which affects the range of plant taxa mentioned significantly. Several studies highlight that rural and oasis populations maintain extensive ethnobotanical knowledge due to limited access to modern healthcare and strong oral transmission systems (Eddouks 2017). The multifunctional role of medicinal plants used for therapy, food, rituals, and pastoral practices also expands the number of useful taxa, as documented in comparable oasis systems.

So, the high number of plant taxa reported in this study reflects the synergistic influence of rich ecological diversity and deeply rooted cultural knowledge, both of which sustain an extensive traditional pharmacopoeia in the Ziz Valley.(Chaachouay 2019).

Diversity of medicinal plant families

The ethnobotanical analysis revealed that the local community gave names to many plants belonging to various families, and they are thus significant in traditional pharmacology. Figure 4 shows the number of species in each plant family. Lamiaceae had the most representative family with 14 plant taxa (10.3% of the total). The observed taxonomic distribution is similar to the study by Fadili, Jeddi and Youssef (Fadili 2017, Jeddi 2021, Youssef 2025), in which Lamiaceae, Asteraceae and Apiaceae are prevailing respectively in Errich in High Atlas, Mernissa in the Rif, and the south of Tétouan-Rif. In the same way, the highest frequencies were reported: 21.95% of Lamiaceae in Djebel Aissa, Algeria (Senouci 2019) and 10.23% of Lamiaceae in the Fez-Meknes region (Tlemcani, 2023)10.23%. The significance of Lamiaceae in Morocco is great, which is reflected in the large number of active compounds contained in this family, its medicinal and therapeutic applications, its high adaptability, and its substantial economic importance (Nieto 2017, Uikey 2024). It was succeeded by Apiaceae (10 taxa, 9.29%), and Fabaceae (8 plant taxa, 5.71%), which are in line with Algerian studies. The Poaceae (6 taxa, 3.9%) was also significantly represented, and the association with the value of relative ecological dominance and the main role in local therapeutic actions was observed. Such convergence of taxonomy implies that the groups have adaptive benefits in water-limited environments and are sources of bioactive therapeutic compounds (Sayed-Ahmad 2017). This dominance of Lamiaceae is also mentioned by El Mansouri in this area. Those moderately represented (5-6 species each) were the family Cucurbitaceae, the family Zingiberaceae, and the family Anacardiaceae, which are known to be useful in antioxidant and wound-healing activities (Bammou 2015), Lawsonia inermis (Lythraceae, 1 taxon), commonly referred to as henna, and popular in beautification and ritualistic works, was also mentioned in the survey, as well as the two plant taxa of the family Zygophyllaceae, Zygophyllum Nevertheless, these species were not as prevalent as taxonomically, but they are crucial in ethnopharmacology (Chaachouay 2019).

These findings demonstrate a high relationship when it comes to the utilisation of plants in the treatment of the Moroccan desert. The ongoing use of certain plant families in different locations highlights their ability to thrive in these conditions and their proven healing effects, which have been passed down through generations. This emphasises the important relationship between environmental challenges and local healing traditions.

Table 3. List of medicinal plants used by the studied population. Caption: PS: Plant Statut (S :Spontaneous ; C: Cultivated .I :Imported); U:Use (Md: Medicinal; Cul, Culinary ;Cos: Cosmetic ;F:Foadder); UV: use value ;RFC: relative frequence of citation ;FUV: Family use value ;PS: Plant statut (S: Spontaneous; C: Cultivated; I: imported; O:Other); U: Use;T:Toxicity HT: High toxicity; LT: Low Toxicity ;N: Non Toxic; NI :Non Indicated

Scientific name	**Voucher Number**	**Famillies**	**Vernacular name**				**UV**	**RFC**	**PS**	**U**	**T**
			Arabic	**Arabic transliteration**	**Berber**	**Berber transliteration**					
Aizoanthemopsis hispanica (L.) Klak	ZIZ001	Aizoaceae	Lghessal	lɣssal	Taghassult	taɣasoult	0.018	0.005	S	Md	N I
Hammada articulata Moq. O.Bolòs & Vigo	ZIZ002	Amaranthaceae	Ramt	/ramt/	Astay	Astaj	0.018	0.005	S		N
Pistacia lentiscus L.	ZIZ003	Anacardiaceae	L'btem	Lbtˁa:m			0.009	0.003	S	Md	N
Pistacia atlantica Desf.	ZIZ004		Drou/lqwaw ech	/dˁru/ /lkwaweʃ/			0.009	0.003	S	Md	N
Allium cepa L.	ZIZ005	Amaryllidaceae	Lbasla	/l-basla/	Azalim	Azalim	0.018	0.005	C	Cul ;Md	N
Allium sativum L	ZIZ006		Thoumza	/θu:ma/			0.009	0.003	C	Cul ;Md	N
Aloe vera L. Burm.f	ZIZ007	Asphodelaceae	Aloevera	/Olivi:ra/			0.009	0.003	S	Md	N
Daucus carota L.	ZIZ008	Apiaceaea	Khizzou /Sefrania	/Xizw/			0.018	0.005	C	Cul	N
Foeniculum vulgare L.	ZIZ009		Besbass	/Bsbasˁ/			0,009	0.003	C	Md	N
Apium graveolens L.	ZIZ010		Lkrafess	/Lkra:fsˁ/			0.018	0.005	C	Cul; Md	N
Carum carvi L.	ZIZ011		Karwiya	/Krwija:/			0.018	0.005	C	Md	N
Coriandrum sativum L.	ZIZ012		Lkasbour /lkazbour	/Qu:zbur/			0.018	0.005	C	Cul ;Md	N
Petroselinum crispum Mill. Fuss	ZIZ013		Lmaadnous	/Mʔʕdʕnu:s/	Abzil /Amaadnous	Abzil / Ama:dnous	0.018	0.005	C	Cul; Md	N
Ammodaucus leucotrichus Coss .and Durieu	ZIZ014		Camoun suffi	/Lka:mu:nsˁu:fi:/	Ikkamen	Ikkamen	0.027	0.008	C	Md	N
Cuminum cyminum L.	ZIZ015		Lkamounn	/Lka:mu:n/			0.027	0.008	C	Cul; Md	N
Pimpinella anisum L.	ZIZ016		Hebethlawa	/hbt ħla:wa:			0.018	0.005	I	Md; Cul	N
Nerium oleander L.	ZIZ017	Apocynaceae	Defla	/ðˁa:fla:/	Alili	a:li:li:	0.005	0.001	S	Md	T
Calotropis procera Aiton.	ZIZ018	Asclepiadaceae	L'ouchr / krounka	/l-ʕuʃr / kru:ŋka/	Tourja /Tourza	Turja / Turza	0.027	0.008	S	Md	H
Caralluma europaea (Guss.) N.E.Br	ZIZ019		Daghmous	/da:ɣmu:s/	Tikiwt	Tikiwt	0.018	0.005	S	Md ;Mel	N
Agave americana L.	ZIZ020	Asparagaceae	Sabra	/sˁa:ba:r/			0.009	0.003	S	Md	N
Artemisia herba-alba Asso.	ZIZ021	Asteraceae	Chih	/ʃiħ/			0.073	0.021	S	Md	LT
Brocchia cinerea Delile.	ZIZ022		Lguartoufa	/l-gartu:fa/	Timgout	Timgut	0.018	0.005	S	Md	N
Chamaemelum fuscatum L.	ZIZ023		Lbaboundz lkhal	/l-ba:bu:nʒ l-xa:/			0.009	0.003	S	Md	N

Chamaemelum nobile L.(All)	ZIZ024		Lbabounj	/lbabunʤ/			0.032	0.009	S	Md	N
Artemisia arborescens L.	ZIZ025		Chiba	/ʃiba/			0.027	0.008	C	Md	LT
Carlina gummifera (L.) Less.	ZIZ026		Dad	/da:d/			0.005	0.001	S	Md	H
Sonchus oleraceus L.	ZIZ027		Tifaf	/tifa:f/	wagerin, tadgami	wagerin, tadgami	0.009	0.003	S	Md	NI
Saussurea costus (Falc.) Lipsch.	ZIZ028		Lqast lh'nd	/l-qa:st l-hənd/			0.005	0.001	I	Md	NI
Warionia saharae Benth. & Coss	ZIZ029		Karmous dbaa	/karmu:s dbaʕ/	Tazougart/Afessas	Tazugart / afessas	0.009	0.003	S	Md	NI
Arctium lappa L.	ZIZ030		Lasiqa	/la:siqa/			0.005	0.001	S	Md	N
Tanacetum annuum L.	ZIZ031		Lbabounjzrak	/l-ba:bu:nʒ zra:k/			0.018	0.005	S	Md	NI
Eruca sativa Mill.	ZIZ032	Brassicaceae	Lwarguia/lkhoudra	/l-wargiya / l-xu:dra/		Akerkaz	0.082	0.024	C	Cul	N
Brassica rapa L.	ZIZ033		Laft	/laft/			0.027	0.008	C	Cul	N
Eruca vesicaria Mill.	ZIZ034		Lharra	/l-ħa:rra/	Tazakht	Tazaχt	0.009	0.003	C	Md	N
Brassica oleracea L.	ZIZ035		Lmkawar	/l-mkawər/			0,009	0,003	C	Cul	N
Berberis vulgaris subsp. Australis (Boiss.) Heywood	ZIZ036	Berberidaceae	Bousman,	/bu:sma:n/	izzirki, ighris	izzirki, iɣris	0.005	0.001	S	Md	NI
Opuntia ficus-indica (L.) Mill	ZIZ037	Cactaceae	hendia, zaâboul	/hendiya, zaʕbu:l/			0.018	0.005	S	Cul; Md	N
Cannabis sativa L.	ZIZ038	Cannabaceae	Lkif	/l-ki:f/			0.018	0.005	O	Md	HT
Capparis spinosa L.	ZIZ039	Capparaceae	Kabbar	/kabbar/	Taylalout	Tajla:lut	0.009	0.003	S	Md	NI
Vaccaria hispanica (Mill) Rauschert	ZIZ040	Caryophyllaceae	Tighighcht	/tigiɣʃt/			0.027	0.008	S	Md	NI
Herniaria hirsuta L.	ZIZ041		Hrastlahjar	/ħra:st l-ħaʒa:r/			0.009	0.003	S	Md	NI
Corrigiola telephiifolia Pourr.	ZIZ042		Sarghina	/sarɣi:na/			0.018	0.005	S	Md	NI
Atriplex nummularia Lindl.	ZIZ043	Chenopodiaceae	Lgtoflmaleh	/l-gtuf l-ma:ləħ/			0.018	0.005	S	Md, F	N
Chenopodium ambrosioides L.	ZIZ044		Mkhinza	/mxinza/			0.005	0.001	S	Md	LT
Suaeda vermiculata Forssk.	ZIZ045		Souede	/sɔu̯ɛda/			0.027	0.008	S	Med F	NI
Citrulus colocynthis L.	ZIZ046	Cucurbitaceae	L'hadja/l'handel	/l-ħa:dʒa / l-ħandel/	Aferziz	a:ferzi:z	0.009	0.003	S	Md	T
Cucumis sativus L.	ZIZ047		Lkhyar	/l-xya:r/			0.009	0.003	C	Cul	NT
Cucurbita lagenaria Forsk.	ZIZ048		Slaoui	/slawi/			0.009	0.003	C	Cul: Md	NT
Cucurbita pepo L var pepo	ZIZ049		Lguer'aalhamra	/l-gerʕa: l-ħamra/	Tagrwayt	ta:grwa:ʤt	0.009	0.003	C	Cul	NT
Citrullus lanatus Thunb.	ZIZ050		Dellah	/dəllaħ/			0.009	0.003	C	Cul	NT
Cucurbita pepo L.	ZIZ051		Lguer'aalkhadra	/l-gerʕa: l-xa:dra/			0.009	0.003	C	Cul	NT
Cucumis melo L.	ZIZ052		Lmnoun	/l-mənnu:n/			0.009	0.003	C	Cul	NT
Juniperus phoenicia L.	ZIZ053	Cupressaceae	Aaraar	/ʕa:ra:r/	Taqa	ta:qa:	0.009	0.003	S	Med	NI
Tetraclinis articulata (Vahl)Mast	ZIZ054		Aaraar	/ʕa:ra:r/			0.009	0.003	S	Md	NI

Juglans regia L.	ZIZ055	Juglandaceae	Lguergua'e/ SwaK	/l-gərgaʕ/ SwāK			0.005	0.001	S	Md ;Cos	N
Ephedra sp	ZIZ056	Ephedraceae	Daghmous	/da:ɣmu:s/			0.018	0.005	S	Md; Mel	NI
Croton tiglium L.	ZIZ057	Euphorbiaceae	Hebtlmalk	/ħebt l-ma:lk/			0.005	0.001	I	Md	NI
Euphorbia cornuta Pers.	ZIZ058		Oumlbina	/ʔu:m l-bi:na/	Aghou'n igra	Aɣu'n igra	0.009	0.003	S	Md	NI
Vicia faba L.	ZIZ059	Fabaceae	Lfoul	/l-fu:l/	Ibawen	i:ba:wen	0.009	0.003	C	Cul	N
Arachis hypogaea L.	ZIZ060		Kawkaw	/ka:wka:w/			0.018	0.005	C	Cul	N
Cicer arietinum L.	ZIZ061		Lhammas	/l-ħamma:s/			0.018	0.005	C	Cul	N
Trigonella foenum-graecum L.	ZIZ062		Lhalba	/l-ħalaba/			0.018	0.005	C	Md	N
Ceratonia siliqua L.	ZIZ063		Lkharoub	/l-xa:ru:b/	Tikharroubt /tassilghwa	ti:xa:rru:bt /ta:ssi:lɣwa:	0.027	0.008	S	Md	N
Medicago sativa L.	ZIZ064		Lfassa	/l-fa:ssa/			0.027	0.008	C	Cul; Fr	N
Retama monosperma (L.) Boiss	ZIZ065		Rtamˡ	/rtam/	Algou /tilkit	a:lgu: / ti:lki:t	0.036	0.011	S	Other	NI
Retama sphaerocarpa (L.) Boiss	ZIZ066		Rtam	/rtam/	Algou /tilkit	a:lgu: / ti:lki:t	0.009	0.003	S	O	NI
Glycyrrhiza foetida Desf.	ZIZ067		Aarksouss	/ʕa:rksu:s/			0.018	0.005	S	Md	N
Acacia raddiana Sav.	ZIZ068		Talh	/ta:lh/	Amrad	a:mra:d	0.055	0.016	S	Md	N
Crocus sativus L.	ZIZ069	Iridaceae	Zaafran	/zaʕfra:n/	Aze'four/Azegour	a:ze'fu:r /a:zegu:r	0.027	0.008	O	Md	N
Salvia rosmarinus (L.) Schleid.	ZIZ070	Lamiaceae	Iklilljabal/Azir	/ikˈli:l l-ʤa:bal / ʔaˈzi:r/	Azir	a:zi:r	0.036	0.011	S	Md	N
Origanum compactum Benth.	ZIZ071		Zaatarˡ	/zaʕtar/			0.027	0.008	S	Md	LT
Origanum majorana L.	ZIZ072		Merdedouch	/merdədu:ʃ/			0.027	0.008	C	Cul	N
Mentha pulegium L.	ZIZ073		Fliyou	/fli:yu:/	Afliyou	afli:ju:	0.018	0.005	S	Cul	N
Calamintha officinalis Moench.	ZIZ074		Manta	/manta/			0.018	0.005	S	Cul	N
Mentha spicata L.	ZIZ075		Ne'anae	/naʕnaʕ/			0.018	0.005	C	Md	N
Ocimum basilicum L.	ZIZ076		Lhbak	/l-ħbaq/	tawchkint	ta:wʃki:nt	0.027	0.008	S	Md	N
Lavandula angustifolia Miller	ZIZ077		Lkhzama	/l-xza:ma/			0.009	0.003	S	Md	NT
Lavandula dentata L.	ZIZ078		Jeaada				0.009	0.003	S	Md	NT
Marrubium vulgare L.	ZIZ079		Merriwa	/mərriwa/	Timrwit	azu:kni:	0.018	0.005	S	Md	T
Mentha suaveolens Ehrh	ZIZ080		Merssita	/mərsi:ta/	timijja	ti:mi:ʤʤa:	0.009	0.003	S	Md	N
Ajuga iva L.	ZIZ081		Chentgoura	/ʃentgu:ra/	Tiwrart n'bizan	ti:wra:rt n'bi:za:n	0.018	0.005	S	Md	NI
Thymus saturejoides L.	ZIZ082		Za'itra	/zaʕi:tra/			0.018	0.005	S	Md ;Ar	N
Salvia officinalis L.	ZIZ083		Salmia	/salmiya/	Azoukni		0.009	0.003	S	Md;Ar	N
Cinnamomum verum J.Presl	ZIZ084	Lauraceae	Lkarfa	/l-qarfa/			0.055	0.016	I	Md ;Ar	N

Cinnamomum camphora(L).J.Presl	ZIZ085		Al-kafur	/al-kafuːr/			0.055	0.016	I	Md	T
Laurus nobilis L.	ZIZ086		Aasa sidna moussa	/ʕaːsaːsiːdnaː muːsaːː/			0.018	0.005	O	Md; Ar	N
Aloe succotrina Lam.	ZIZ087	Asphodelaceae	Aloe vera	/l-aluːʔiːra/			0.027	0.008	C	Md, Cos	N
Asphodelus microcarpus Rchb	ZIZ088	Asphodelaceae	Berouague	brwaːg			0.018	0.005	S	Md	NI
Urginea maritima (L.) Baker	ZIZ089		Bsaldib	/l-ʕansal / bsal diːb/	Athalim n'wushen	/aːwaːlim n wushen/	0.055	0.016	S	Md	T
Linum usitatissimum L.	ZIZ090	Linaceae	Z'ri'at el kettane	/zriʕat el kətaːtaːn/			0.027	0.008	C	Md	NI
Lawsonia inermis L.	ZIZ091	Lythraceae	L'henna	/l-ħenna/	L'henna	/l-ħenna/	0.027	0.008	C	Cos ;Md	N
Malva neglecta Wallr.	ZIZ092	Malvaceae	Lkhabiza	/l-xbiːza/			0.082	0.024	S	Cul; Md	N
Abelmoschus esculentus L. Moench	ZIZ093		Mloukhia	/l-mluːxya/			0.027	0.003	C	Cul ;Med	
Moringa oleifera auct.	ZIZ094	Moringaceae	Moringa	/muriŋa/	lmouringa	lmurinjga	0.009	0.003	I ;C	Mes	N
Ficus carica L.	ZIZ095	Moraceae	Lkarmuss /Chriha	/l-karmuːs / ʃriːħa/	Akzar	akzaːr	0.027	0.008	C	Md	N
Myrtus communis L.	ZIZ096	Myrtaceae	Reyhane	/reːħan/			0.027	0.008	S	Md	N
Syzygium aromaticum (L.) Merr. & L.M.Perry	ZIZ097		Oud Nwar	/ʕuːd nwaːr/			0.018	0.005	I	Md	LT
Eucalyptus spp.	ZIZ098		Klitou /kalitous	/kliːtuː / kaːliːtuːs/			0.009	0.003	S	Md	NI
Myristica fragrans Houtt.	ZIZ099	Myristicaceae	Bsibissa/ gouzttib	/bsiːbisa / guːz ttib/			0.009	0.003	I	Md	NI
Olea europaea subs. europaea L.	ZIZ100	Oleaceae	Zitoune		Azemour	azemuːr	0.027	0.008	S ;C	Cul;Md;Co s	N
Fraxinus ornus L.	ZIZ101		Lsan t'ayr				0.005	0.001	S	Md	N
Phoenix dactylifera L.	ZIZ102	Arecaceae	Nkhal	/nxal/	Tazdayt	taːzdajt	0.009	0.003	C	Cul; Md	N
Papaver somniferum L.	ZIZ103	Papaveraceae	Lkharchacha	/l-xarʃaʃa/			0.082	0.024	S	Md	LT
Papaver rhoeas L.	ZIZ104		Belaaman	/bəlaʕmaːn/	Takbbout	takbbuːt	0.018	0.005	S	Md	LT
Sesamum indicum L.	ZIZ105	Pedaliaceae	Jenjlan	/ʤəndʒlaːn/			0.036	0.011	I	Cul ;Md ;Cos	N
Cedrus atlantica (Endl). Manetti	ZIZ106	Pinaceae	Ketranerkik	/ketraːn rkiːk/			0.018	0.005	S	Md	T
Pinus halepensis Mill.	ZIZ107		Dbagh	/dbaːɣ/			0.018	0.005	S	Md	NI
Piper longum L.	ZIZ108	Piperaceae	Dhar felfel	/dˤaːr fəlfəl/			0.018	0.005	I	Md	N
Zea mays L.	ZIZ109	Poaceae	Dra	/draːː/;l'k'bal	Amzgour	amzguːr	0.027	0.008	C	Cul; Md	N
Hordeum vulgare L.	ZIZ110		Ch'a'ir	/ʃaʕiːr/	Timthrin	Timθrin	0.009	0.003	C	Cul	N
Triticum aestivum L.	ZIZ111		Z'ra'e	/zraʕ/	Irden	Irden	0,005	0,001	C	Cul	N
Stipa tenacissima L.	ZIZ112		Lhalfa	/l-ħalfa/	Ari/Agrri /Awri	aːri / agrr i / aːwri	0.036	0.011	S	O	

Rumex vesicarius L.	ZIZ113	Polygonaceae	Lhmida	/l-ħmiːda/			0.036	0.011	S	Md	NI
Portulaca oleracea L.	ZIZ114	Portulacaceae	R'jldjaja	/rʒəl ddʒaːdʒa/			0.027	0.008	S	Md	N
Punica granatum L.	ZIZ115	Lythraceae	Roumane	/ruːmmaːn/	Taremant	taːremant	0.027	0.008	C	Cul; Md	N
Nigella sativa L.	ZIZ116	Ranunculaceae	Sanouje /Shanouj /hebba souda	/saːnuːʒ / ʃaːnuːʒ / ħebba suːda/			0.018	0.005	I	Md	N
Ziziphus lotus L.	ZIZ117	Rhamnaceae	Sedra/ Nbegu	/sedra / nbəgu/	Azegough	azegouɣ	0.009	0.003	S	Md	N
Malus domestica (Borkh).Borkh	ZIZ118	Rosaceae	Teffah	/teffaːħ/	Adfouy	adfuːj	0.082	0.024	C	Cul	N
Malus × domestica (Suckow) Borkh	ZIZ119		Teffah	/teffaːħ/	Adfouy	adfuːj	0.041	0.012	C	Cul	N
Prunus dulcis Mill.	ZIZ120		Lluz	/l-luːz/	Taluzt	taluːzt	0.018	0.005	C	Cul; Cos	N
Cydonia oblonga Mill.	ZIZ121		Sferjel	/sfərʒəl/			0.036	0.011	C	Cul	N
Rosa ×damascena Mill.	ZIZ122		Lward'lbeldi	/l-waːrd l-beldi/	Tighfert	t i ɣ f e r t	0.018	0.005	C	Cos; Md	N
Prunus armeniaca (L.)	ZIZ123		Lmeshmash	/l-meʃmaːʃ/	ameshmash	a m e ʃ m a ʃ	0.045	0.013	C	Cul	N
Ruta montana (L.)	ZIZ124	Rutaceae	Lfijel	/l-fiːdʒəl/			0.018	0.005	S	Md	T
Citrus aurantium subf. sinensis (L.) M.Hiroe	ZIZ125		Limoune	/liːmuːn/	Taletchint	t a l e t ʃ i n t	0,027	0,008	C	Cul	N
Citrus limon L.	ZIZ126		Lhamed	/l-ħaːmed/	Assemmou m	a s e m u: m	0.018	0.005	C	Cul ;Md	N
Citrus medica L.	ZIZ127		Trounj /larnaj	/truːndʒ / l-aːrnaːj/	Awenbou'e	a w e n b u	0.018	0.005	C	Md ;Ar	N
Salix alba L.	ZIZ128	Salicaceae	Sefsaf	/sefsaf/			0.018	0.005	S	Other	NI
Argania spinosa L.	ZIZ129	Sapotaceae	Argane	/argan/	Argane	a r g a: n	0.009	0.003	C	Cul; Md; Cos	N
Capsicum annuum L.	ZIZ130	Solanaceae	Lfelfla lharra	/l-fel fla l-ħaːrra/			0.009	0.003	C	Cul	N
Hyoscyamus albus L.	ZIZ131		Guinguit	/giːŋgiːt/			0.018	0.005	S	Md	NI
Solanum lycopersicum L.	ZIZ132		Maticha	/maːtiːʃa/	amatash	a m a: t a ʃ	0.027	0.008	C	Cul	N
Solanum melongena L.	ZIZ133		Denjal	/denʒal/	abeljane	a b e l dʒ a n e	0.027	0.008	C	Cul	N
Solanum tuberosum L.	ZIZ134		Batata	/bataːta/	ibatataen	l b a t a t e n	0.027	0.008	C	Cul	N
Datura stramonium L.	ZIZ135		Chdaqjmel	/ʃdaːq dʒmel/			0.027	0.008	S	Md	HT
Tamarix aphylla (L.) H.Karst.	ZIZ136	Tamaricaceae	L'aadba	/l-ʕaːd ba/	Taqawt	t a: q a w t	0.027	0.003	S	Md	N
Urtica mauritanica L.	ZIZ137	Urticaceae	Lhaurriga lmalssa	/l-ħawrrigal-malssa/			0.009	0.003	S	Md	N
Urtica auren L.	ZIZ138		Lhourigua lharsha	/l-ħuːriga l-ħarʃa/			0.009	0.003	S	Md	N
Verbena officinalis L.	ZIZ139	Verbenaceae	Louiza	/luːiːza/			0.009	0.003	C	Md	N
Vitis vinifera L.	ZIZ140	Vitaceae	L'aanab /Zbib	/l-ʕaːnab / zbiːb/			0.045	0.013	C	Cul	N

Asphodelus fistulosus L.	ZIZ141	Asphodelaceae	Lberouag	/l-berwaːg/			0.018	0.005	S	Md	T
Zingiber officinale Roscoe	ZIZ142	Zingiberaceae	Skinjbir	/skiːnʤbiːr/			0.009	0.003	I	Md; Cul	N
Aframomum melegueta K.Schrum	ZIZ143		Lgouza sahraouiya	/l-guːza sahraːwiya/			0.036	0.011	S	Md	LT
Curcuma longa L.	ZIZ144		Lkharkoum	/l-xarkuːm/			0.027	0.008	I	Cul; Md	N
Elettaria cardamomum (L.)Maton	ZIZ145		Ka'akalla	/kaʕkalla/			0.036	0.011	I	Md	NT
Alpinia officinarum Hance	ZIZ146		Khoudenjal/ khdanjal	/xuːdenʤaːl/ xdanʤaːl/			0.018	0.005	I	Md	NT
Zygophyllum gaetulum Emb. & Maire	ZIZ147	Zygophyllaceae	Laagaya	/laʕaːya/			0.018	0. 005	S	Md	NT
Peganum harmala L.	ZIZ148		/l-ħarmal/	ħaːrmaːl	Iharmal (iharmal)/Ah ourmal	i ħ a r m a: l / a ħ u r m a: l	0.027	0. 008	S	Md	HT

Ethnotaxonomy

The study of the ethnotaxa, the vernacular classification of flora by local people, throws into the sun a dualist system of nomenclature that reflects the cultural diversity of the area. Each taxon has received many names applied both in the Arabic dialect **(Darija**) and in the Berber language (**Tamazight**) by the Amazigh and Arab communities of the valley with the ethnoecological flavor of a mixture of adjacent ecological and ethnic influences to give a name to it. Dominant families, Lamiaceae (10,3%), Apiaceae (9,29), and Fabaceae (5,71), in general, are especially represented in the vernacular lexicon, and such species as Pistacia atlantica Desf. (receives the common vernacular name Lbtem, as an ethnotaxon) or Haloxylon scopariom Pomell (Ramt as an ethnotaxon, Astay as a Berber ethnotaxon). A particularly noteworthy example is a case of the endemic Warionia saharaea L. where the taxon is named **karmus 'dba** in arabe and **afessas** in Berber. These species exemplifies how the ethnotaxa can encode knowledge about the specifics of ecology and use of plant species adapted to the hyper-arid environments (Bellakhdar 1997, Eddouks 2002) The arid zones of Morocco, where the annual rainfall is less than 200 mm, have fostered the emergence of a sophisticated vernacular classification, or this knowledge system, shaped through generations of empirical observation and practice, that represents an essential adaptive framework ensuring survival under harsh climatic constraints (Karmaoui 2022) This local nomenclature is transmitted orally from generation to generation. (44,91% Intergenerational parental transmission) is a form of immaterial heritage threatened by Cultural erosion associated with socio-economic modernization, a source of which is the urgency to record these ethnotaxa before their extinction.

Analysis of dominant families

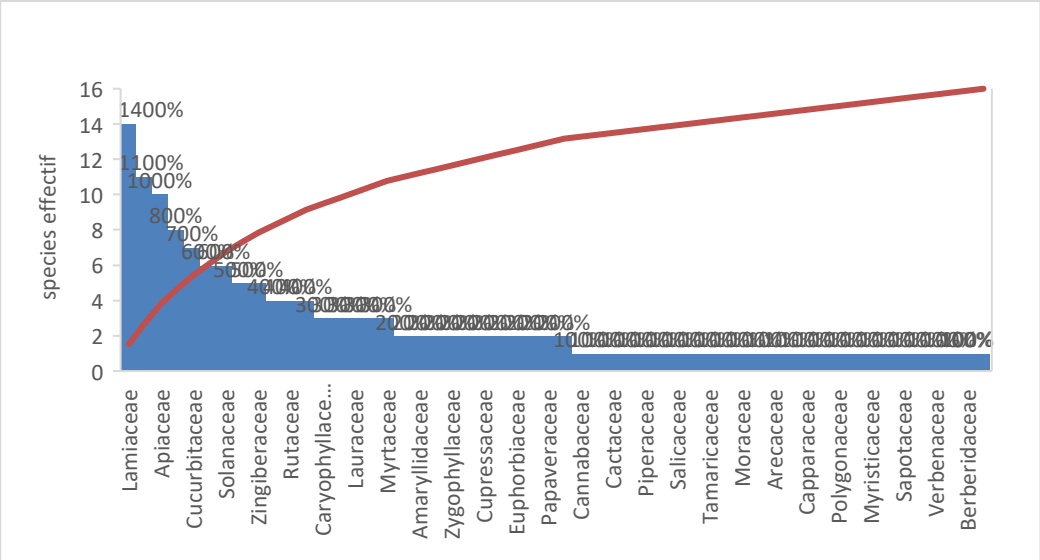

Figure 4. Number of plant taxa recorded per family

The Family Use Value (FUV) analysis indicates that there is a distinct hierarchical distribution of ethnobotanical value of plant families in the Ziz Valley (Figure 5). Lamiaceae has the greatest FUV (0.306), followed by Rosaceae (0.24) and Fabaceae (0.235). The following layer is Ranunculaceae and Apiaceae (both 0.18), Brassicaceae (0.154), Asteraceae (0.137), Liliaceae (0.136) and Malvaceae (0.135). The families of medium interest are Lauraceae (0.128), Poaceae (0.127), and Zingiberaceae (0.126), and Poaceae (0.113) has moderate significance. Families of FUV value lower than 0.10 consist of Cactaceae (0.082), Rutaceae (0.081), Solanaceae (0.077), and Polygonaceae (0.072). The minimum values are found in Euphorbiaceae (0.063), Juglandaceae (0.054), Pinaceae (0.054) and Papaveraceae (0.045). This distribution represents the abundance of species in families as well as their aggregate cultural value in traditional practices. This is indicated by the richness of Lamiaceae (FUV=0.306) in the Ziz Valley: this family has been strongly adapted to dry conditions and has accumulated aromatic essential oils that have antimicrobial and digestive abilities that are well known. *officinalis* and *M. pulegium*, *O. compactum* and *T. satureioides* are all significant species and are also commonly used in gastrointestinal illnesses (29.82% of all medicinal uses in our survey). The popularity of the Rosaceae (FUV=0.24) is explained by the utilisation of cultivated fruit trees, M. communis Poir, *P. armeniaca* L, *C. oblonga* Mill, which belong to the oasis agriculture that is implemented in the culinary and medicinal industry. Besides therapeutic and fodder values, Fabaceae (FUV=0.235), in particular, *A. raddiana* Savi and *T. foenum-graecum* L, fix their nitrogen in soils with degraded soil properties.

We also have a similar FUV hierarchy with Moroccan ethnobotanical inventories: Lamiaceae dominated (16 taxa), with the most important family in the northeast of Morocco, northeastern Morocco, and Lamiaceae (10.78) and Apiaceae (5.12) were

the most dominant families in 743 morphologically defined medicinal taxa inventoried over Morocco. Benamara found similar patterns in nearby Algeria, where Lamiaceae (13%), Asteraceae (13%), Apiaceae (7%), and Fabaceae (5%) were found to depict trends of common ethnopharmacological practices in the Maghreb according to Mediterranean-Saharan floristic continuity (Benamara 2022). Our census results show high values of Rosaceae due to the presence of an oasis microclimate of Ziz Valley that supports the growth of pomology, but a pure Saharan environment has lower proportions of Rosaceae.

Such a family hierarchy indicates arid ethobotany patterns of the world (Abduraimov 2023). These results were found in arid Uzbekistan, where Asteraceae, Fabaceae, and Lamiaceae had the highest numbers of occurrences in 529 medicinal species, and Asteraceae and Fabaceae had the highest numbers of occurrences in Saudi Arabian deserts (Ullah 2020) The abundance of Fabaceae in the arid regions of the Rajasthani region in India is similar since the phytochemicals cover a broad spectrum in drought-tolerant legumes (Shreya 2023). The convergent evolutionary importance of the Lamiaceae, the Apiaceae, and the Fabaceae is due to the convergence of evolutionary adaptations of terpene-rich essential oils (Lamiaceae), aromatic coumarins (Apiaceae), and nitrogen-fixing alkaloids (Fabaceae) in the Mediterranean, Saharan, Middle East, and Asian drylands. However, the geographical variations between the Moroccan oases (where Rosaceae values are high) and Arabian deserts (where they are lower) and also others suggest that the general tendencies are not always unchangeable, and local agricultural activities and variability of microclimates create individual ethnobotanical patterns in each arid ecosystem.

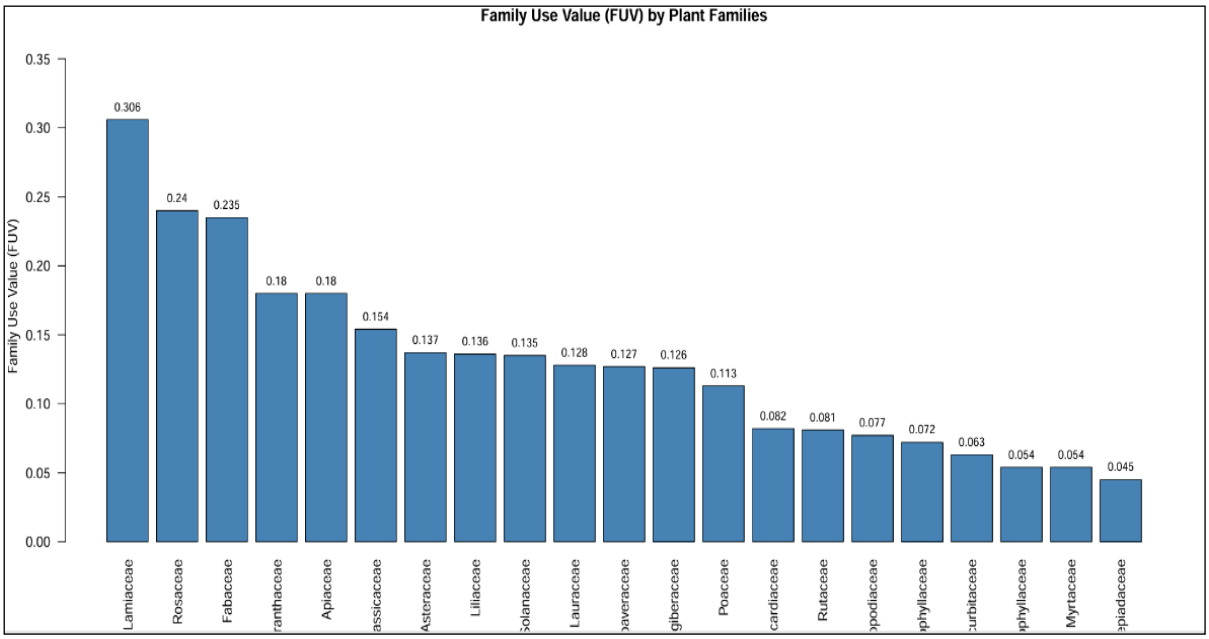

Figure 5. Family use value

The RFC analysis shows that *Eruca sativa*, *Malva neglecta*, *Papaver somniferum* and *Malus communis* are the species with the highest values (RFC = 0.024), and this suggests that the knowledge of these species is well spread among informants (Bemanar 2026). *Artemisia herba-alba* (RFC = 0.021) is the most commonly used medicinal plant in the arid zone of Morocco, as confirmed by recent inventories (Bencheikh 2024). Exotic species (*Cinnamomum zeylanicum* and *Cinnamomum camphora*) (RFC = 0.016) are also quite frequent, thanks to the souks' commercial network (Tlemcani 2023). This list of the RFC highlights the strength of the transgenerational flow of local ethnobotanical knowledge.

Plant status

Status of used plants

In this section of the survey, we focused on the status of the plants used, whether Spontaneous, Cultivated, or imported. The results indicated that 56.5% were Spontaneous, 37.3% were cultivated, 5.6% were strictly imported, while 0.6% were either cultivated or imported. Fig. 5. According to Ilić (Ilić *et al*. 2022), the essential oils of *Origanum spp* L obtained from wild flowers exhibited the highest antioxidant activity, whereas those from cultivated non-shaded plants showed the lowest activity. Similarly, Yang et al. reported that cultivated samples of *Z. striolatum* L. contained higher levels of soluble sugars, soluble proteins, and total saponins, while wild samples were richer in K, Na, Se, vitamin C, and total amino acids. Furthermore, cultivated *Z. striolatum* showed greater antioxidant potential, whereas wild *Z. striolatum* demonstrated stronger

hypoglycemic activity; similar results are shown in other studies, such as antitumor and antioxidant activities of *Clinopodium vulgare* L. (Petrova 2023) and *Z. striolatum* nutritional and biological activity (Yang 2023).

The predominance of spontaneous taxa (56.5%) highlights the central role of wild plants in the phytotherapy of the Ziz Valley. Their importance is deeply rooted in both the ecological context and the socio-economic realities of the population. Ecologically, wild plants thrive under harsh environmental conditions, high temperatures, water scarcity, and poor soils, which stimulate the production of potent secondary metabolites such as phenolics, terpenoids, flavonoids, and alkaloids. Numerous studies confirm that plants exposed to abiotic stress tend to accumulate higher levels of bioactive compounds, resulting in superior antioxidant, anti-inflammatory, and antimicrobial properties compared to cultivated plants. This adaptive chemical richness explains why wild medicinal plants are highly valued in traditional therapeutic practices.

From a cultural perspective, the strong reliance on spontaneous flora reflects long-standing indigenous knowledge systems and a close relationship between communities and their natural environment. The population, particularly in rural and oasis areas, has traditionally depended on wild resources due to limited access to modern healthcare, geographical isolation, and the persistence of oral transmission of ethnobotanical knowledge (Ajebli 2019) Socio-economic constraints also reinforce this dependence: households with restricted income or limited access to urban markets often rely on freely available wild plants for both medicinal and domestic use, as reported in multiple Moroccan ethnobotanical studies (Bouyahya 2017). This trend was observed previously in the immediate study zone. El Mansouri has highlighted the socioeconomic significance of harvesting wild plants in the Rissani oasis as a care option with low costs to populations with low access to formalities in rural settings (El Mansouri 2011). Thus, the extensive use of spontaneous species by the population is the result of a combined effect of ecological adaptation, cultural heritage, and socio-economic necessity. Their abundance, accessibility, and high pharmacological potential make wild plants an essential component of local phytotherapy, explaining their strong representation in the inventory of the Ziz Valley.

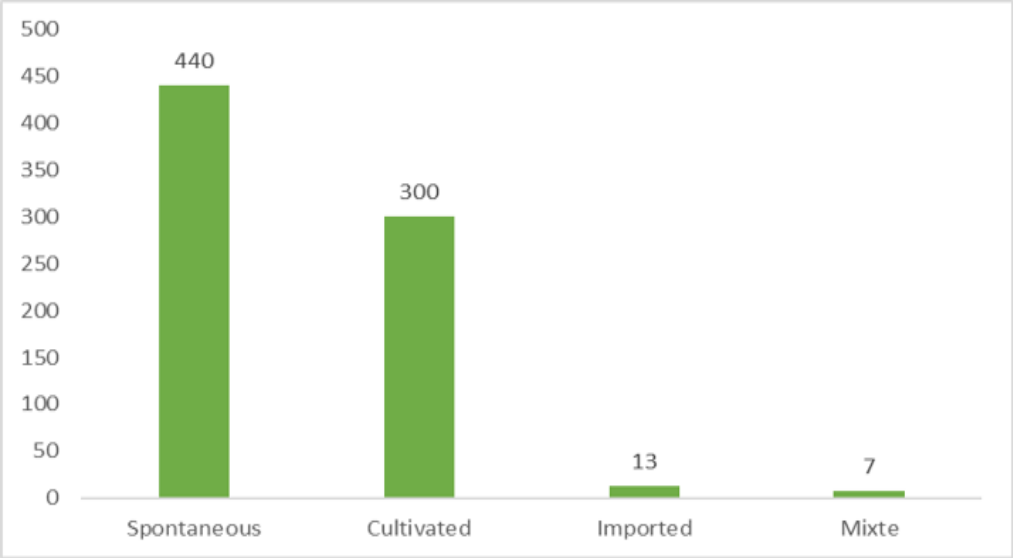

Figure 6. Used plant status

Procurement strategies

The prevalence of spontaneous (wild) plants (56.5%), compared to cultivated (37.3%), and imported species (5.6), is key to the importance of the wild flora in the local phytotherapy in the Ziz Valley. This high dependence indicates their ecological assimilation into oasis ecosystems and their high ecobotanical awareness and connection to environmental availability, which underscores the importance of biodiversity in traditional healthcare. The socioeconomic factors also rationalise this trend, as rural poverty, limited healthcare services, high pharmaceutical costs, and market difficulties contribute to reliance on free wild resources in cases of geographical isolation. Wild plants perform better phytochemically because arid and UV conditions lead to increased biosynthesis of phenolics, flavonoids, terpenoids and alkaloids, and often have better bioactivities than cultivated plants (Ilić 2022); demonstrated better antioxidant capacity (EC50 4.78 mg/mL) of wild Origanum vulgare than cultivated ones, whereas Yang reported greater mineral content, vitamin C activity and marginal hypoglycemic efficacy of wild *Zingiber striolatum* L. than of cultivated types (Yang 2023). Thus, the presence of wild and domesticated plants is

complementary, although excessive harvesting is a threat to biodiversity, which requires sustainable approaches such as selective domestication.

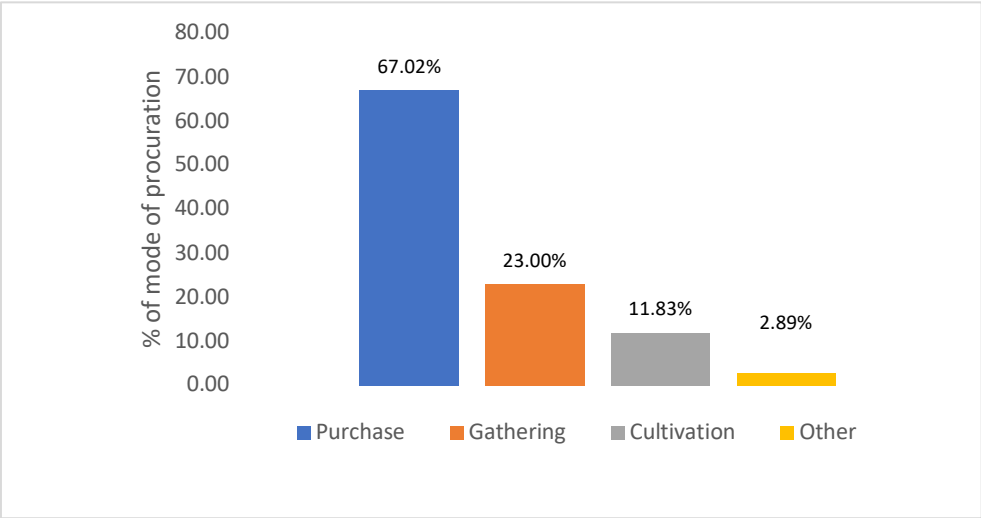

Figure 7. Methods of plant procurement

Plant part used

Based on our ethnobotanical survey, it was found that local communities use different parts of plants, such as leaves, flowers, stems, roots, and seeds. The most common part (63%), as shown in Figure 7, was leaves, probably because of their availability and concentration of bioactive compounds, as in the case of A. herba-alba L. Fruits (12%) and seeds (8%) have been used to a smaller degree, with the toxic species like *P. harmala* L requiring cautionary measures. Sustainability is a concern because of overexploitation since harvesting of underground parts (5%, e.g., *J. oxycedrus* L) is carried out. Both safety (toxicity of Euphorbia and *C. procera* L) and ecological risks (exposure of cork oak) can be identified, such as the harvested parts of the plant (bark and latex: 3% each). The proportion of leaves in the harvested parts of the plant dominates (63%). This finding is directly in line with the findings of Bieski in Brazil (64.5%) (Bieski, 2012) and agrees with the trends to be expected by Ullah (Ullah *et al*. 2020) and Merrouni (Merrouni, 2021). Such a predisposition is justified by the fact that such a resource is always available and is rich in bioactive compounds, as in A. herba-alba L. On the other hand, the emphasis on the seeds by Chaachouay (Chaachouay 2019) and (more than 30) is contrasted with our data (8%), which might be related to the local floristic or cultural peculiarities. The significance of our research is a critical aspect regarding the ecological effects of harvesting. Even though the percentage of roots (5) and bark (3) usage appears to be insignificant, it is a severe threat to biodiversity. Picking roots of *Juniperus oxycedrus* or cork oak bark would ruin the existence of the individual, not as leaf picking does. Merrouni also mention this ecological vulnerability in the northeast of Morocco. Moreover, the alertness towards the toxic species mentioned (*Peganum harmala*, *Euphorbia sp*), which is reflective of the safety hazards reported by Elhouari (Haouari, 2018), cannot be done without specific management of these resources. In brief, the fact that our results correspond with the global literature helps to conclude that, although leaf harvesting is one of the methods that help species to become resilient, the exploitation of the most vital organs is something that needs to be conserved as soon as possible.

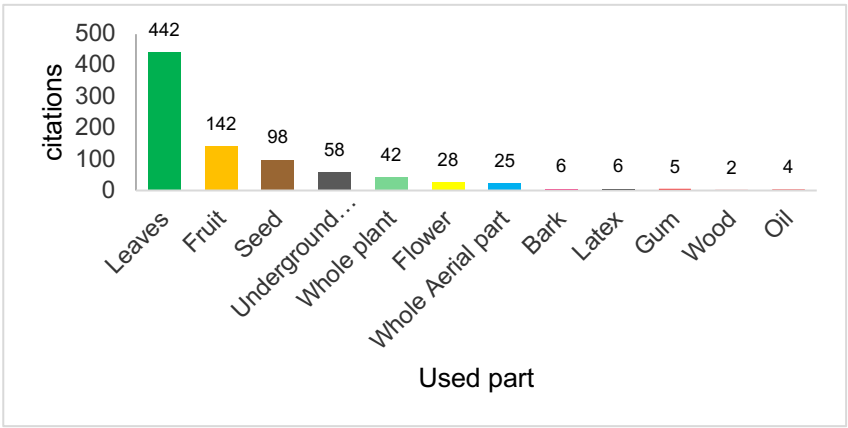

Figure 8. Plant parts used

Ethnopharmacological and nutritional analysis of cited plants

Plant uses

The analysis showed a strong hierarchical distribution with medicinal uses taking the majority of citations, Figure 9 (61.4%), then culinary 24.6%, cosmetic 10.5%, mixed 1.8%, multivarious 0.8%, and other usage 0.9%. This medical predominance is indicative of geographic isolation, poor access to healthcare, and socioeconomic factors-55.9% of the informants live in rural regions and have poor access to pharmaceuticals (Arraji et al. 2024, El-Ghazouani et al. 2024, Elhasnaoui et al. 2024). The lack of knowledge (44.91% and 42.27%), the transmission of knowledge through parental heritage and tribal traditions encourage the therapeutic use, whereas harsh environmental conditions (precipitation less than 120 mm/year and temperatures more than 45 °C stimulate the biosynthesis of pharmacologically active secondary metabolites (Ben Salem & El Alami El Filali 2024).

Our results are in line with those of Eddouks (Eddouks *et al*. 2017), with 69% medicinal use in the province of Errachidia;, with 65% in the Rif (Hemmami *et al*. 2023), with 71% in the Algerian Sahara, suggesting that Maghrebi ethnopharmacological traditions are shared. The increased culinary diversity (24.6-15-18 in exclusively Saharan settings) is an oasis agricultural diversity (Hosni *et al*.2020).

On a worldwide scale, the trend is comparable to the arid areas of the world: Iranian pastoral communities 73% (Ghorbani *et a*l. 2012) and Mexican deserts 68% (Dávila-Rangel *et al*.2024) are characterised by comparable medicinal predominance due to the lack of medical care and natural adaptation to the environment (Ncube *et al*. 2012). The high cosmetic consumption (10.5) is an indication of distinctive Maghrebi cultures using henna (Lawsonia *inermis*) and argan oil (Argania *spinosa*) (Bellakhdar 1997).

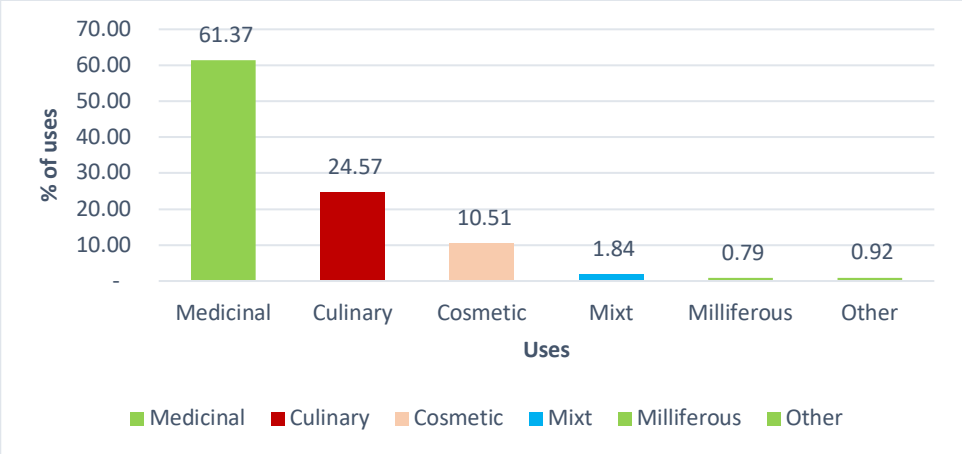

Figure 9. Plant uses in %

Medicinal uses of cited plants

Pharmacological uses

Distribution of respondents by the body systems targeted by their use of medicinal plants or traditional therapeutic products, with a total of 531 citations divided into 13 pathological groups. The most common therapeutic indication by a very significant margin (227 cases; 42.7%) was the digestive system. The nervous system (68 cases, 12.8%) and dermatological use (65 cases, 12.2%) ranked second and third, accounting for almost 68% of all respondents. The cases dealing with hair conditions were 39 (7.3%), whereas the other category (25) and urogenital disorder (24) were in the middle range. Other indicators like respiratory (19), endocrine (20) and immune (10) systems were minorities, and the remaining, such as circulatory, oropharyngeal, and ophthalmic systems, represented only a few respondents: 7, 7 and 4 respondents, respectively.

This finding is entirely in line with ethnobotanical tendencies at national and regional scales. In Morocco, a study in Guercif, North East, showed that gastrointestinal disorders were more than a factor of over 35% of all indications recorded by herbalists and local populations in the Taza-Al Hoceima-Taounate region (Benali *et al*. 2017). Likewise, in their ethnobotanical work on the Taza province, which covers an area of more than 202 medicinal species, that the digestive system is frequently the most mobilised in ethnobotanical records and applications (Hajli *et al*. 2024), and also verified this dominance by pinpointing 36 taxa that had digestive signs. In terms of the nervous system, stated that in the Province of Guercif, the extensive use of sedative and anxiolytic plants was reported, which was associated with the prevalence of sleep disorders and stress in the rural Moroccan communities. Ennabili also touched on the issue of the dangers of uncontrolled plant

valorisation in Morocco and emphasised the necessity to develop more effective models of pharmacovigilance (Ennabili *et al*. 2023).

At the Maghreb level, in Algeria (Bissa region), it has been indicated that gastrointestinal disorders (28.24% of all recorded uses) (Senouci *et al*. 2019, Hassaine & Benmalek 2023) in the Algerian Sahara (Adrar region) have supported that the digestive system (32% of all reported uses) is the leading therapeutic indication, and then respiratory conditions (18.8) (Hassaïne & Benmalek 2023). The overlapping information in the Maghreb indicates a common ethnopharmacological basis, where traditional medicine mainly deals with chronic digestive pathology that is interlinked with water quality conditions, along with local eating patterns. Miara established the digestive dominance in the semi-arid region of Naama (southwestern Algeria), with *Teucrium polium* L. being the most mentioned plant (fidelity index: 60%) (Miara *et al*. 2021). These results correspond to the previous results in the Western High Atlas of Morocco, where digestive, respiratory, and urinary diseases are the major targets of medicinal plants.

The hegemony of the digestive system is supported everywhere on an international level. Khajuria (Uttarakhand), India, of the digestive disorders (Khajuria *et al*. 2021), which Panmei also support in the Zeliangrong communities of Manipur (174 use reports of 44 digestive species), (Panmei *et al.* 2019). Rupani, who collected 119 ethnodermatological records in the Indian subcontinent, also supports the dermatological uses (Rupani & Chavez 2018). Arnason, among Q'eqchi' Maya healers in Belize, noted that it was predominantly are digestive and nervous system disorders, which supports the cross-cultural universality of these therapeutic priorities (Arnason *et al*. 2022). Lastly, similar to Belhouala and Benarba (Belhouala & Benarban 2021) in a multi-regional Algerian study, the low representation of ophthalmic and circulatory system disorders in the current study is in line with their finding, which was also explained by the fact that these two sectors are more likely to prefer conventional medicine, which is viewed as more complicated and clinically sensitive. Combined, these convergent findings, Morocco and the Maghreb to arid zones, South Asia, and Latin America, make a call in favour of making medicinal plants that can be used in digestion and neuromotor ways the subject of ethnopharmacological and pharmacological research in future.

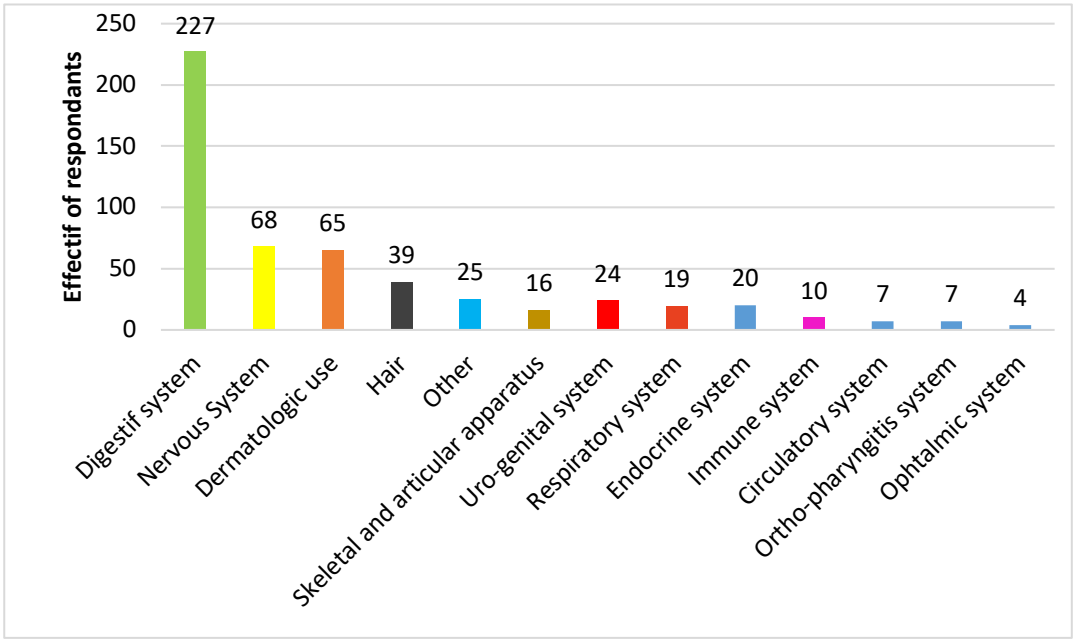

Figure 10. Pharmacological use of cited plants

Condition of used plants

Various plant forms use were mentioned by surveyed population, fresh, dried, powdered, or in combinations, as illustrated in Figure 11. Analysis of these modes of use reveals a clear dominance of the dried form (33.8%), which aligns with findings from comparable ethnobotanical studies across Morocco and the broader Maghreb region. in the Settat, west of Morocco, dried condition is dominant, primarily for infusion and decoction preparations, confirming that dehydration is a widespread practice for preserving plant bioactive compounds and extending shelf life (Lahyaoui et al. 2025) This cultural and utilitarian anchoring of the dried form is further reinforced by El hasnaoui who noted that women traditionally manage the drying and storage of medicinal plants in northeastern Moroccan communities, reflecting a deeply rooted domestic pharmacopoeia

(Elhasnaoui 2025) The fresh form (20.9%) also holds significance in local practice. Asraoui documented a preference for fresh plants in 61.7% of remedies in the Taza Province (Asraoui 2025), arguing that fresh material better preserves thermolabile active principles The combined preparations "Fresh and Dried" (14.5%) and "Dried and Powder" (10.1%) suggest flexible, context-dependent practices, as documented by El Ghazal et al. in the Fes-Meknes region, where both fresh and dried forms were mobilised depending on the targeted condition (Ghazal 2025).

In arid and semi-arid zones, such as Errachidia province, Sara (Tlemcani 2023, Hassaïne 2023) confirmed that dried plant preparations dominate Saharan pharmacopoeias, with infusions and decoctions accounting for over 80% of recorded uses (Adouane 2022). The marginal occurrences of "Fresh + Powder" (0.7%) and "Fresh + Dried" (1.6%) warrant further qualitative investigation to distinguish genuine therapeutic practices from potential data collection artefacts, as similarly cautioned by Bensizerara (Bensizerara 2025). Overall, the predominance of the dried form calls for in-depth qualitative ethnobotanical inquiry to elucidate its cultural, ecological, and therapeutic drivers.

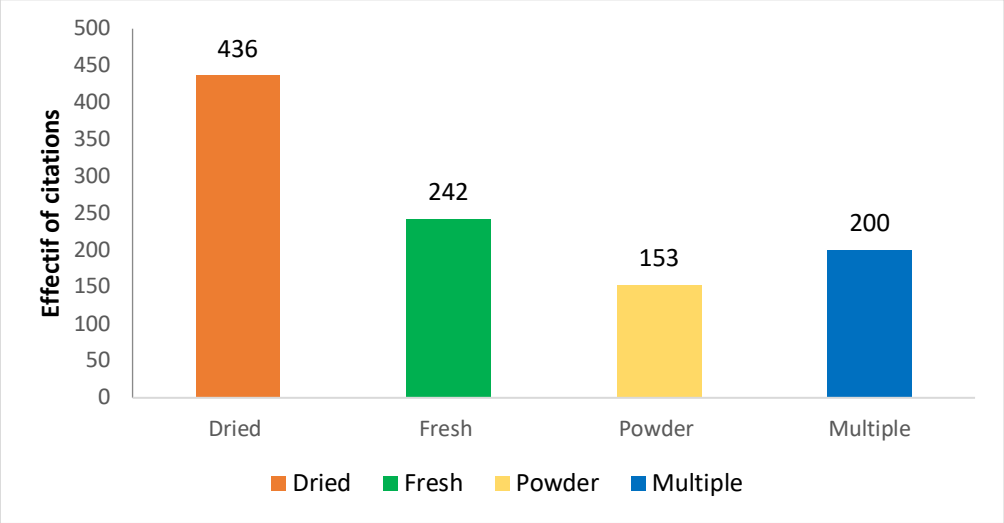

Figure 11. Conditions of use of plants

Methods of preparation

Our survey findings are consistent with the general trends reported in the literature on Moroccan ethnobotany. Infusion was the most common form of preparation (32.4%), maceration (18.7%), decoction (15.9%), and cooking (12.6%). This trend is in support of the results of Chaachouay (Chaachouay 2019), who reported infusion as the most common technique (53.9%), then decoction (22.1%), and cooking (15.16%), whereby infusion is the best extractor of active constituents, and it neutralises or removes the toxicity of some remedies Chaachouay on the same note, found infusion to be the preeminent method of preparation (41.6%), with cataplasm (30.36%) and decoction (27.6%) coming in second and third, respectively (Chaachouay 2020) The dominance of infusion in our research site overlap with the findings of a survey study carried out in the Kenitra Province, which showed that infusion (42.3 %) was the most common preparation, followed by decoction (16.9%) and cooking (13.2%) (Amina Essamett 2026) In contrast, some studies on other parts of Morocco note decoction to be the most common method: a survey of 544 informants in north-central Morocco found decoction (38.3%) and infusion (19.2%) to be the most used modes of preparation (Lefrioui 2024). A similar study in Taounate (Northern Morocco) also found decoction as the leading (42%), then powder (27%), and infusion (13%) (Jeddi, 2024). Another survey was carried out in the Safi Province, which registered that the most common method was decoction (42%), then infusion (20%), powder (18%), and poultice (17%)(Lemhadri 2002). These territorial differences imply that the relative use of infusion to decoction in the Ziz Valley is both the agro-climatic factors of the arid-zone flora and the cultural transmission patterns that are specific to the Draa-Tafilalet ethanosphere, which is in line with the previous results of El Alami (El Alami, 2017), with infusion at 12%. At a more general scale of Morocco, in the Rif, the most widespread method is decoction, which is explained by its ability to concentrate the most active substances and neutralise some of the toxic ones; the share of which in relation to other approaches (fumigation, maceration) does not exceed 5.2% (Chaachouay 2022).

Toxicity and adverse effects of plants as reported by the population

Analysis of reported responses. Figure 13 shows a secure profile with 73% of responses with no toxicity observed, which correlates with a previous study in Tafilalet, 68% (Ajebli& Eddouks 2019), rare effect 17% is a few lower than Belhaj et al. in

Central High Atlas, 24% of side effects observed with plants diabetic users in northern Morocco, Taza, Ghabbour et al. observed 20% of side effects (Ghabbour 2024) principally caused by errors of documentation or doses. Near aour study area, in Maaskar, Algeria, Benarba report 70% of side effects or intoxication, but in the other side 30% are essentially caused by excessive use of P. harmala and C. colocynthis L (Benamara *et al*. 2022); in Tunisia, in arid area, it was also reported a lower confidence of use with 35% of side effects .9% of frequent side effects need a special and narrow care, it seems to a narrow therapeutic index users of plants, like Datura stramonium, Urginea maritima L or Papaver somniferum L, most cited in our survey and also toxic (Ben Salem & El Alami El Filali 2024); Chaachouay reported similar rates of adverse effects (8-12) associated to topical uses of some Euphorbiaceae and Solanaceae (Chaachouay e*t al*. 2021). Reported cases of poisoning mainly involve tropane alkaloids (Datura, Hyoscyamus), cardiac glycosides (Nerium, Urginea), and opioids (Papaver). Najem report that the important causes of risk are confusion in identification, which leads to intoxication or therapeutic ineffectiveness (Najem *et al*. 2021)

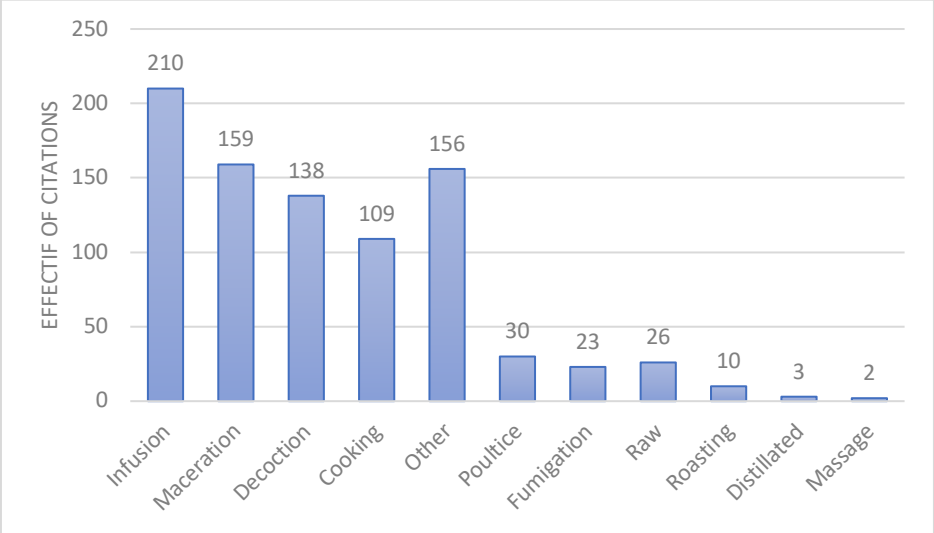

Figure 12. Methods of preparation

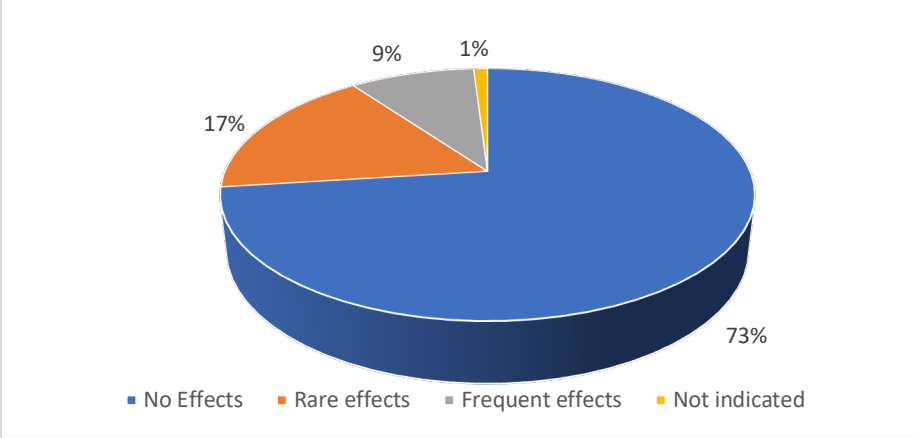

Figure 13. Toxicity and adverse effects of the cited plant

Plant toxicity and adverse effects of highly cited plants

Toxicity, toxic compounds and side effects of the most frequently cited plants are presented in Table 4.

Table 4. Toxicity and adverse compounds of the most frequently cited plants according to bibliographic references.

Plants	**Toxic compounds**	**Mechanisms of intoxication and adverse effects**
Papaver somniferum L	Morphine, Codeine, Thebaine, Noscapine, Berberine, Noscapine, Papaverine, Sanguinarine, Tubocurarine (Alcaloïdes) (Shaghaghi 2019)	Analgesic, Antitussive, Sedative, Vasodilator, Antimicrobial agents, Muscle relaxant (Labanca 2018) Opioid Dependence, Respiratory Depression, Cognitive and Neuromuscular Disturbances, Nausea and Vomiting, Sexual Dysfunction (Jan, 2021)
Datura stramonium L	5H-Dibenzodiazépines (Flavonoid) Atropine and Scopolamine (Alkaloids)	Sedative and antipsychotic (Okpashi 2021); hyperthermia, tachycardia, delirium, coma and death(Sharma 2021)
Nerium oleander L	Oleandrine, nerine, digitoxigenin (cardiac glycosides)	Na+-K+ ATPase pump in the cellular membrane (Shi 2025, Shridhar 2022). Cell infiltration with haemorrhage and severe negative lung.Inflammatory cell infiltration, Myocardial degeneration (Dey 2020)
Urginea maritima L / *Silla maritima* L	Gamabufotaline-3-O-α-L-rhamnopyranoside,12β-hydroxyscillirosidine, Arénobufagine-3-O-α-L-rhamnopyranoside, Scilliroside (Kord 2021) (Manganyi 2021)	Cardiac disturbance, hyperkalemia, Nausea, profuse vomiting, abdominal pain, diarrhea (Merad 1997).
Chenopodium ambrosioides L	Ascaridole; Carvacrol; Caryophyllene oxide Camphor	Toxicity is mediated by affecting mammalian mitochondrial oxidative phosphorylation effect depends on the presence of ferrous iron Fe^{2+} (Everton, 2025) gastrointestinal tract dysfunctioning troubles, and worms parasitaemia (Kasali 2021), anthelmintic (Kliks 1985)
Asphodelus microcarpus Pomel 1932		Myeloid Cell antiproliferative (Hosni, 2020)
Aframomum melegueta, Roscoe K. Schum.Analgesic (		Umukoro 2007); immunosuppressive (Latif 2024)

Conclusion

The 148 plant taxa of 52 botanical families were reported in our Ziz Valley ethnobotanical survey. Lamiaceae, Apiaceae and Fabaceae are especially important to therapeutic application in the local culture of healing. The digestive system accounted for the largest proportion of medicinal uses (42.7 %), followed by nervous disorders (12.8 %), skin conditions (12.2 %) and hair-related problems (7.3 %), whilst respiratory and urogenital disorders were less common. Medicinal type of use has the highest share (61.37%), then there is food (25%), cosmetics (11%), mixed (2%), honey production (1%) and other (1%), showing the definitive preponderance of the therapeutic use over other types of use. The data concerning the knowledge transmission should be given special attention. The process of knowledge transmission is basically in parental (44.91%) and tribal (42.27%) modes. On the contrary, the fact that it depends only on the modern means of documentation (5.55%) raises many questions about the future preservation and conservation of this cultural heritage. The fact that this figure is at best that large a credit in itself to the susceptibility of a knowledge system that remains virtually entirely dependent on oral memory. The level of safety was also addressed, and 73 % of the respondents affirmed that they did not suffer any negative consequences, which is empirical support for such practices, although some of the identified risks ought to make these respondents more careful and pay much attention to the awareness campaigns.

Our study documents also the biocultural and Ethnotaxonomy (language Darija/Tamazight) of the ZIZ Valley, where the vernacular names of plants reflect ancestral empirical knowledge. Transmitted orally (family 44.91%, Tribes 42.27%), this ethnopharmacological wealth is now seriously threatened by rural exodus, youth disengagement, and the near-total absence of written documentation (5.55%).To prevent the irreversible loss of this knowledge, essential for survival in arid environments, urgent measures are needed: digital archiving, transmission programs, and legal protection through the Nagoya Protocol.

The community-led cultivation programmes can also help in alleviating the strain caused by the ever-growing wild plant population that is currently facing the risk of being hunted down without any form of regulations. Finally, the gradual adoption of these therapies in the institutional care systems with well-founded safety must be made in reality by collaborating with the local stakeholders rather than imposing them.

Future research needs to be informed by additional understanding of the mechanistic basis of classical formulations. It is also allied to the necessity to ensure a clear legal safeguard of indigenous knowledge and fair benefit-sharing agreements, which can arise in case of scientific valorisation of such knowledge, one of the features that have been ignored in such studies far too often. The ethnobotanical potential of the Ziz Valley in this respect is exceptionally high, the rigorous scientific investigation of which has only just begun.

Declarations

List of abbreviations: RBOSM: Réserve de Biosphère des Oasis du Sud-Marocain;UV: use value;RFC: relative frequency of citation; FUV: Family use value

Ethics approval and consent to participate: Consent was always obtained from participants before the interviews began and after explaining the study objectives.

Consent for publication: The participant shown in Figure. 2 agreed to have their image published

Data Availability: Available from the corresponding author upon request. Competing interests: The author declares that there is no conflict of interest.

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Authors' contributions: A.H: Study design, Survey conduction, manuscript writing, data analysis, and interpretation. M. B: Data analysis and interpretation. A. B: Data analysis and writing. A B: Fieldwork supervision. A K: Study design and supervision, contribution to methodology, manuscript improvement, and review editing. All authors read, reviewed, and approved the final version of the manuscript. K M: Study design and supervision, contribution to methodology, manuscript improvement, and review editing. All authors read, reviewed, and approved the final version of the manuscript. A M: Study design and supervision, contribution to methodology, manuscript improvement, and review editing. All authors read, reviewed, and approved the final version of the manuscript. B M: Study design and supervision, contribution to methodology, manuscript improvement, and review editing. All authors read, reviewed, and approved the final version of the manuscript. Y L: Data analysis and writing. H O: Data analysis and writing. A S: Cartographic conception

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Literature cited

Abdelhameed RF, Nafie MS, Hal DM, Nasr AM, Swidan SA, Abdel-Kader MS, Eltamany EE. 2022. Comparative cytotoxic evaluation of *Zygophyllum album* root and aerial parts of different extracts and their biosynthesized silver nanoparticles on lung A549 and prostate PC-3 cancer cell lines. Pharmaceuticals 15(11): 1334. doi: 10.3390/ph15111334

Ahmed A. 2021. Characterization of selected wild medicinal plants of Zygophyllaceae from Balochistan through integrated approaches. [PhD dissertation, University of Balochistan, Quetta, Pakistan].

Ait El Cadi M, Khabbal Y, Alaoui K, Faouzi MA, Bruno E, Mahraoui L, Cherrah Y. 2008. Antidiarrheal activity of *Zygophyllum gaetulum*. Phytothérapie 6(1): 2-4.

Ait El Cadi M, Makram S, Ansar M, Khabbal Y, Alaoui K, Faouzi MA, Cherrah Y, Taoufik J. 2012. Anti-inflammatory activity of aqueous and ethanolic extracts of *Zygophyllum gaetulum*. Annales Pharmaceutiques Françaises 70(2): 113-116. doi: 10.1016/j.pharma.2011.10.006

Ajebli M, Eddouks M. 2019. The promising role of plant tannins as bioactive antidiabetic agents. Current Medicinal Chemistry 26(25): 4852-4884.

Albuquerque UP, De Lucena RFP, da Cunha LVFC, Alves RRN. 2019. Methods and techniques in ethnobiology and ethnoecology. Springer, Cham, Switzerland.

Albuquerque UP, Ramos MA, de Lucena RFP, Alencar NL. 2013. Methods and techniques used to collect ethnobiological data. In: Albuquerque UP, De Lucena RFP, da Cunha LVFC, Alves RRN. (eds) Methods and Techniques in Ethnobiology and Ethnoecology. Pp. 15-37. Springer, New York, USA.

Amsalu N, Mengiste D, Birhanu L, Awoke A, Getnet GT. 2025. Ethnobotanical investigation of traditionally used phytomedicines in Jabitehnan district, West Gojjam Zone, Ethiopia. Scientific Reports 15(1): 44926. doi: 10.1038/s41598-025-29297-4

Asraoui F, Ben-Said M, Louajri A. 2025. Ethnobotanical survey of five wild medicinal plants used by local population in Taza province (Northeastern Morocco). Multidisciplinary Science Journal 7(2): 2025095. doi: 10.31893/multiscience.2025095

Azwanida NN. 2015. A review on the extraction methods used in medicinal plants, principle, strength and limitation. Medicinal & Aromatic Plants 4: 196. doi: 10.4172/2167-0412.1000196

Bahlil Y, Krouf D, Taleb-Dida N. 2019. *Zygophyllum album* aqueous extract reduces glycemia and ameliorates lipid profile and oxidative damage in hypercholesterolemic-diabetic rats. Nutrition & Food Science 49(1): 141-157. doi: 10.1108/NFS-03-2018-0078

Bahlil Y, Krouf D, Taleb-Dida N. 2020. *Zygophyllum album* aqueous extract reduces protein oxidation and protects endothelial function in hypercholesterolemic-diabetic rats. South Asian Journal of Experimental Biology 10(4): 213-220.

Bammou M, Daoudi A, Sellam K, Rhaffari LE, Ibijbijen J, Nassiri L. 2015. Ethnobotanical survey of Asteraceae family used in Meknes-Tafilalet region (Morocco). International Journal of Innovation and Applied Studies 13(4): 789-815.

Bar FMA, Alonazi R, Ibrahim S, Elekhnawy E, Alqarni MH, Foudah AI, Samra RM. 2025. Lipoidal fractions of *Zygophyllum simplex* exhibit antibacterial and wound-healing activities in a Pseudomonas aeruginosa-infected burn model. Scientific African 29: e02875. doi: 10.1016/j.sciaf.2024.e02875

Barros HRDM, Ferreira TAPC, Genovese MI. 2012. Antioxidant capacity and mineral content of pulp and peel from commercial cultivars of citrus from Brazil. Food Chemistry 134(4): 1892-1898. doi: 10.1016/j.foodchem.2012.03.091

Belhaj S, Dahmani J, Belahbib N, Zidane L. 2020. Ethnopharmacological and ethnobotanical study of medicinal plants in the High Atlas Central, Morocco. Ethnobotany Research and Applications 20: 1-15. doi: 10.32859/era.20.31.1-15

Bellakhdar J. 1997. La pharmacopée marocaine traditionnelle: médecine arabe ancienne et savoirs populaires. Ibis Press, Paris, France.

Bemanar K, Benelfakir K, Benamar S. 2026. Ethnobotany in Morocco from 1990 to 2023: Part II - Analysis of floristic diversity, conservation status and treated diseases. Ethnobotany Research and Applications 33: 1-28. doi: 10.32859/era.33.1.1-28

Benamara R, Mohamed K, Hadjadj K, Righi K, Benarba B. 2022. Spontaneous medicinal plants used by the population of Ain Sefra province (Southwest Algeria): an ethnobotanical study. South African Journal of Botany 12: 937-949. doi: 10.38150/sajeb.12(6).p937-949

Benarba B, Belabid L, Righi K, Bekkar AA, Elouissi M, Khaldi A, Hamimed A. 2015. Ethnobotanical study of medicinal plants used by traditional healers in Mascara (North West of Algeria). Journal of Ethnopharmacology 175: 626-637. doi: 10.1016/j.jep.2015.09.030

Bencheikh N, Elbouzidi A, Baraich A, Bouhrim M, Azeroual A, Addi M, Mothana RA, Al-Yousef HM, Eto B, Elachouri M. 2024a. Ethnobotanical survey and scientific validation of liver-healing plants in northeastern Morocco. Frontiers in Pharmacology 15: 1414190. doi: 10.3389/fphar.2024.1414190

Bencheikh N, Elbouzidi A, Baraich A, Bouhrim M, Azeroual A, Addi M, Mothana RA, Al-Yousef HM, Eto B, Elachouri M. 2024b. Ethnobotanical survey and scientific validation of liver-healing plants in northeastern Morocco. Frontiers in Pharmacology 15: 1414190. doi: 10.3389/fphar.2024.1414190

Bensizerara D, Khemili A, Hassad R, Aroua K, Mellal H, Chenchouni H. 2025. Ethnobotanical survey and ecological approach of medicinal and aromatic plants in Algeria. Ethnobotany Research and Applications 32: 1-31. doi: 10.32859/era.32.1.1-31

Berzou S, Taleb-Senouci D, Guenzet A, Krouf D. 2014. Zygophyllum gaetulum attenuates hypercholesterolemia and protects against oxidative stress in rats fed a high-cholesterol diet. Journal of Experimental and Integrative Medicine 4(4): 255-260. doi: 10.5455/jeim.140714.or.007

Bieski IGC, Rios Santos F, de Oliveira RM, Espinosa MM, Macedo M, Albuquerque UP, de Oliveira Martins DT. 2012. Ethnopharmacology of medicinal plants of the Pantanal region (Mato Grosso, Brazil). Evidence-Based Complementary and Alternative Medicine 2012: 272749. doi: 10.1155/2012/272749

Biosafety U. 2011. The Nagoya Protocol on Access and Benefit-sharing. Retrieved 15/01/2026 from https://www.cbd.int/abs/about/

Bouaouinate A, Ait Moussa A. 2015. Les oasis du Maroc face au tourisme, quelles chances pour le developpement durable? In: XIVth Annual International Conference of Territorial Intelligence Sustainable Development of Vulnerable Territories. ASET, France.

Boufous H, Marhoume F, Chait A, Bagri A. 2017. Ethnopharmacological survey of medicinal plants with hallucinogenic effect and plants used against pain, inflammatory diseases, diabetes and urinary lithiasis in Zagora, Morocco. Journal of Complementary Medicine Research 7(2): 385-393. doi: 10.5455/jcmr.2017.7.041

Boukemara H. 2016. Effect of two medicinal plants Anvillea garcinii and *Zygophyllum gaetulum* on the immune system. [PhD dissertation, Université 8 Mai 1945, Guelma, Algeria].

Bourgou S, Megdiche W, Ksouri R. 2017. The halophytic genus *Zygophyllum* and *Nitraria* from North Africa: a phytochemical and pharmacological overview. In: Medicinal and Aromatic Plants of the World - Africa. Pp. 345-356. Springer. doi: 10.1007/978-94-024-1120-1_13

Bouyahya A, Bakri Y, Et-Touys A, Talbaoui A, Khouchlaa A, Charfi S, Abrini J, Dakka N. 2017. Antibiotic resistance and mechanisms of action of essential oils against bacteria. Phytothérapie 16: 1-10. doi: 10.1007/s10298-017-1118-z

Brahim I. 2019. Encyclopedie des plantes tamazight. Books By Language Arabic, Morocco.

Capasso A, Omar S, Fkih-Tetouani S, Sorrentino L, Aquino R. 1998. Properties and effects on isolated guinea-pig ileum of *Zygophyllum gaetulum*. Pharmaceutical Biology 36(5): 320-326. doi: 10.1076/phbi.36.5.320.7119

Catullo G, Montmollin, B. d., Radford EA. 2011. Important plant areas of the south and east Mediterranean region: priority sites for conservation (Arabic version). IUCN, Gland, Switzerland.

CBD. 2026. The World Flora Online. In: South African National Biodiversity Institute, JBdG, Tela Botanica and the Missouri Botanical Garden. World Flora Online. https://www.worldfloraonline.org/

Chaachouay N, Azeroual A, Bencharki B, Zidane L. 2022. Herbal medicine used in the treatment of cardiovascular diseases in the Rif, North of Morocco. Frontiers in Pharmacology 13: 921918. doi: 10.3389/fphar.2022.921918

Chaachouay N, Benkhnigue O, Fadli M, El Ayadi R, Zidane L. 2019. Ethnobotanical study of medicinal plants used to treat osteoarticular diseases in the Moroccan Rif, Morocco. Journal of Pharmacy & Pharmacognosy Research 7(1): 454-470. doi: 10.56499/jppres19.644_7.6.454

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019a. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. Heliyon 5(10): e02191. doi: 10.1016/j.heliyon.2019.e02191

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019b. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. Heliyon 5(10): e02191.

Chaachouay N, Benkhnigue O, Zidane L. 2020. Ethnobotanical study aimed at investigating the use of medicinal plants to treat nervous system diseases in the Rif of Morocco. Journal of Chiropractic Medicine 19(1): 70-81. doi: 10.1016/j.jcm.2019.10.003

De Meyer E, Ceuterick M. 2022. Digital Ethnobiology: exploring the digisphere in search of traditional and indigenous knowledge and practices. Ethnobotany Research and Applications 24: 1-8. doi: 10.32859/era.24.35.1-8

Dey P. 2020. The pharmaco-toxicological conundrum of oleander: potential role of gut microbiome. Biomedicine & Pharmacotherapy 129: 110422. doi: 10.1016/j.biopha.2020.110422

Eddouks M, Ajebli M, Hebi M. 2017. Ethnopharmacological survey of medicinal plants used in Daraa-Tafilalet region (Province of Errachidia), Morocco. Journal of Ethnopharmacology 198: 516-530. doi: 10.1016/j.jep.2017.01.029

Eddouks M, Maghrani M, Lemhadri A, Ouahidi ML, Jouad H. 2002. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). Journal of Ethnopharmacology 82(2-3): 97-103. doi: 10.1016/S0378-8741(02)00164-2

El-Assri EM, Barnossi AE, Chebaibi M, Hmamou A, Asmi HE, Bouia A, Eloutassi N. 2021. Ethnobotanical survey of medicinal and aromatic plants in Taounate, Pre-Rif of Morocco. Ethnobotany Research and Applications 22: 1-23. doi: 10.32859/era.22.17.1-23

El Aboui FZ, Lahmass M, Ghabbour I, Laghmari M, Benali T, Khabbach A, Hammani K. 2025. Ethnomedical insights into plants used by tribes in the Rif of Al Hoceima and in the Pre-Rif of Taza (two provinces in Northern Morocco). Ethnobotany Research and Applications 30: 1-37. doi: 10.32859/era.30.7.1-37

El Alami A, Chait A. 2017. Ethnopharmacological and ethnobotanical survey of medicinal plants in the Central High Atlas of Morocco. Algerian Journal of Natural Products 5(1): 427-445. doi: 10.5281/zenodo.843894

El Bakouri Z, Meziani R, Bouzelmate H, Rabach B, Jaiti F. 2025. Genetic diversity study of date palm and influencing factors in the Tafilalet palm groves, Morocco. Cahiers Agricultures 34: 3. doi: 10.1051/cagri/2025003

El Kourchi C, Belhoussaine O, Harhar H, Bouyahya A, Kotra V, Rehman IU, Ming LC, Lua PL, Tabyaoui M. 2024. Medicinal and aromatic plants traditionally used to treat metabolic diseases in the Rabat region, Morocco. Journal of Research in Pharmacy 28(4): 1293-1315. doi: 10.29228/jrp.927

El Mansouri L, Ennabili A, Bousta D. 2011. Socioeconomic interest and valorization of medicinal plants from the Rissani oasis (SE of Morocco). Boletin Latinoamericano y del Caribe de Plantas Medicinales y Aromaticas 10(1): 30-45.

Elhasnaoui A, Janah I, El-Haidani A, Lahrach N. 2025. Medicinal knowledge and ethnopharmacological applications of Matricaria pubescens (Desf.) Sch.Bip in the Draa-tafilalet region, Morocco. Ethnobotany Research and Applications 30: 1-9. doi: 10.32859/era.30.8.1-9

Essamett AI, Belmejdoub N, Alaizari H, Ennouali M, Ouhssine M. 2026. Ethnobotanical survey of aromatic and medicinal plants used in Kenitra Province, Morocco. Biomedical and Pharmacology Journal 19(1): 785-795. doi: 10.13005/bpj/3392

Everton GO, Serejo APM, Arruda MO, Mattos MCAB, Gomes PRB, Marinho SC, Silva DADL, Bandeira MDGA, Dantas AR, Filho VEM. 2025. Antioxidant and anticancer activity in vitro of *Chenopodium ambrosioides* L. essential oil. In: Open Science Research XIX. Pp. 47-63. Editora Cientifica Digital. doi: 10.37885/250319071

Fadili K, Sekkate C, Alistiqsa F, Haloui Z, Chakir S. 2017. Ethnobotanical study of medicinal plants from Er-Rich region (Moroccan High Atlas). Acta Botanica Malacitana 42: 99-114. doi: 10.24310/abm.v42i0.2894

Fennane M, Tattou MI. 2008. Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. Flora 1986(1989)

Fennane M, Ibn Tattou M, Matherz J, Ouyahya A, Eloualidi J. 1999. Flore pratique du Maroc-Manuel de détermination des plantes vasculaires (Volume 1). Rabat: : Institut Scientifique, Service d'édition, Av. Ibn Battouta, Agdal. ISBN:9954-0-1456-X.

Fennane M, Ibn Tattou M, Mathez J, Ouyahya A, El Oualidi J. 2007. Flore pratique du Maroc-Manuel de détermination des plantes vasculaires (Volume 2). Rabat : Travaux de l'Institut Scientifique, Série Botanique 38. ISBN: 978-9954-8347-4-9.

Fennane M, Tattou MI. 2012. Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, 2012, n°34 (1), p. 1-9.

Fennane M, Ibn Tattou M, El Oualidi J. 2014. Flore pratique du Maroc-Manuel de détermination des plantes vasculaires (Volume 3). Rabat: Institut scientifique, Université Mohammed V -Agdal. ISBN: 978-9954-20-671-3

Ghabbour I, Ghabbour N, Khabbach A, Louahlia S, Hammani K. 2024. New ethnobotanical know-how characterizing the medicinal flora of the province of Taza (northern Morocco): valorization and quantification of qualitative knowledge. Ethnobotany Research and Applications 29: 1-32. doi: 10.32859/era.29.19.1-32

Ghazal AE, Louafi B, Sebbar K, Mekkaoui AE, Koraichi SI, Abed SE. 2025. An ethnopharmacological survey of medicinal plants used for wound care in the Fez-Meknes region (Morocco). Ethnobotany Research and Applications 30: 1-25. doi: 10.32859/era.30.9.1-25

Haouari EL, El M, Jnah.. 2018. A survey of medicinal plants used by herbalists in Taza (Northern Morocco) to manage various ailments. Journal of Materials and Environmental Sciences 9(5): 1875-1888.

Hachi M, Ouafae B, Hachi T, Mohamed EB, Imane B, Atmane R, Zidane L. 2016. Contribution to the ethnobotanical study of antidiabetic medicinal plants of the Central Middle Atlas region (Morocco). Lazaroa 37: 85-98.

Harborne JB. 1998. Phytochemical methods: a guide to modern techniques of plant analysis. Chapman & Hall, London, United Kingdom.

Harchaoui L, Ouafi S, Meguellati H, Saad S. 2025. Effect of solvent polarity on phytochemical composition and pharmacological properties of *Zygophyllum cornutum*. Pharmaceutical Chemistry Journal 59(1): 63-73. doi: 10.1007/s11094-025-03365-5

Haroun SA, Abualghaith AS. 2015. Evaluation of the allelopathic effect of aqueous extract of *Zygophyllum simplex* L. on *Vicia faba* L. plants. Cytologia 80(3): 363-371. doi: 10.1508/cytologia.80.363

Heinrich M. 2001. Journal of Ethnopharmacology: an interdisciplinary journal devoted to indigenous drugs. Journal of Ethnopharmacology 76(2): 137-138. doi: 10.1016/S0378-8741(01)00272-6

Hoffman B, Gallaher T. 2007. Importance indices in ethnobotany. Ethnobotany Research and Applications 5: 201-218. doi: 10.32859/era.5.0.201-218

Hosni H, Salama A, Abudunia A, Cherrah Y, Ibrahimi A, Alaoui K. 2020. Acute toxicity, cytotoxicity and antiradical effect of the methanolic extract of *Asphodelus microcarpus* leaves. Phytothérapie 18(5): 284-290. doi: 10.3166/phyto-2019-0136

Houssni M, El Mahroussi M, Sbih HB, Kadiri M, Ater M. 2018. Traditional agriculture and agrodiversity in the oases of southern Morocco: case of the Drâa-Tafilalet oases. In: Research and innovation as tools for sustainable agriculture, food and nutrition security. MEDFORUM.

Houssni M, Kassout J, El Mahroussi M, Chakkour S, Kadiri M, Ater M, Petrisor AI. 2023. Evaluation and structuring of agrodiversity in oases agroecosystems of southern Morocco. Agriculture 13(7): 1413. doi: 10.3390/agriculture13071413

Hseini S, Kahouadji A. 2007. Ethnobotanical study of the medicinal flora in the Rabat region (Western Morocco). Lazaroa 28: 79-93.

Ilić Z, Stanojević L, Milenković L, Šunić L, Milenković A, Stanojević J, Cvetković D. 2022. The yield, chemical composition, and antioxidant activities of essential oils from different plant parts of the wild and cultivated oregano (*Origanum vulgare* L.). Horticulturae 8(11): 1042. doi: 10.3390/horticulturae8111042

Jan Y, Peer LA. 2021. *Papaver somniferum*: phytochemistry, biological activity and toxicology; a review. International Journal of Botany Studies 6(4): 753-757.

Janah I, Elhasnaoui A, Ben Bammou M, Amssayef A, Eddouks M. 2024. An overview on pharmacological, ethnomedicinal, and phytochemical investigations of *Zygophyllum gaetulum* Emb. & Maire - an endemic species of southeast of Morocco. Plant Science Today 11(Sp1): 2348-1900. doi: 10.14719/pst.2348

Jeddi M, Ouaritini ZB, Fikri-Benbrahim K. 2021. Ethnobotanical study of medicinal plants in northern Morocco (Taounate): case of Mernissa. Ethnobotany Research and Applications 21: 1-23. doi: 10.32859/era.21.12.1-23

Jeddi S, Ferioun M, Benkhaira N, Jeddi M, Hachlafi NE, Fikri-Benbrahim K. 2024. Ethnobotanical appraisal of indigenous medicinal plants used in the Taounate region (Northern Morocco): qualitative and quantitative approaches. Ethnobotany Research and Applications 28: 1-26. doi: 10.32859/era.28.34.1-26

Kachmar MR, Naceiri Mrabti H, Bellahmar M, Ouahbi A, Haloui Z, El Badaoui K, Bouyahya A, Chakir S. 2021. Traditional knowledge of medicinal plants used in the northeastern part of Morocco. Evidence-Based Complementary and Alternative Medicine 2021: 6002949. doi: 10.1155/2021/6002949

Karmaoui A, Ben Salem A, El Jaafari S, Chaachouay H, Moumane A, Hajji L. 2022. Exploring the land use and land cover change in the period 2005-2020 in the province of Errachidia, the pre-sahara of Morocco. Frontiers in Earth Science 10: 962097. doi: 10.3389/feart.2022.962097

Karmaoui A, Moumane A, El Jaafari S, Menouni A, Al Karkouri J, Yacoubi M, Hajji L. 2023. Thirty years of change in the land use and land cover of the Ziz Oases (Pre-Sahara of Morocco) combining remote sensing, GIS, and field observations. Land 12(12): 2127. doi: 10.3390/land12122127

Kasali FM, Tusiimire J, Kadima JN, Agaba AG. 2021. Ethnomedical uses, chemical constituents, and evidence-based pharmacological properties of *Chenopodium ambrosioides* L.: extensive overview. Future Journal of Pharmaceutical Sciences 7: 153. doi: 10.1186/s43094-021-00306-3

Khabbach A, Libiad M, Ennabili A, Bousta D. 2012. Medicinal and cosmetic use of plants from the province of Taza, Northern Morocco. Boletin Latinoamericano y del Caribe de Plantas Medicinales y Aromaticas 11(1): 46-60.

Kliks MM. 1985. Studies on the traditional herbal anthelmintic *Chenopodium ambrosioides* L.: ethnopharmacological evaluation and clinical field trials. Social Science & Medicine 21(8): 879-886. doi: 10.1016/0277-9536(85)90144-3

Kord A, Hammoudi K, Chader H. 2021. Rodenticidal activity of *Urginea maritima* bulb extract. AGROBIOLOGIA 10(3): 2162-2167.

Kouider H, Mohammed B, Mohammed M, Abdelkader O, Abdelkarim R. 2019. Importance of medicinal plants for the rural population of Djebel Aissa National Park (Southwest Algeria). Lejeunia, Revue de Botanique. doi: 10.25518/0457-4184.1864

Labanca F, Ovesná J, Milella L. 2018. Papaver somniferum L. taxonomy, uses and new insight in poppy alkaloid pathways. Phytochemistry Reviews 17(4): 853-871. doi: 10.1007/s11101-018-9563-3

Latif M, Elkoraichi I, El Faqer O, Wahnou H, Mtairag EM, Oudghiri M, Rais S. 2024. Phytochemical analysis and immunomodulatory activities in vitro and in vivo of *Aframomum melegueta* K. Schum seed extracts. Inflammopharmacology 32(2): 1621-1631. doi: 10.1007/s10787-023-01422-7

Lefrioui Y, Chebaibi M, Bichara MD, Mssillou I, Bekkari H, Giesy JP, Bousta D. 2024. Ethnobotanical survey of medicinal plants used in north-central Morocco as natural analgesic and anti-inflammatory agents. Scientific African 25: e02275. doi: 10.1016/j.sciaf.2024.e02275

Lemhadri A, Achtak H, Lamraouhi A, Louidani N, Benali T, Dahbi A, Bouyahya A, Khouchlaa A, Shariati MA, Hano C, Lorenzo JM, Chen JT, Lyoussi B. 2023. Diversity of medicinal plants used by the local communities of the coastal plateau of Safi Province (Morocco). Frontiers in Bioscience (Scholar Edition), 15(1). doi: 10.31083/j.fbs1501001

Lightfoot DR. 1996. Moroccan khettara: traditional irrigation and progressive desiccation. Geoforum 27(2): 261-273. doi: 10.1016/0016-7185(96)00015-5

Manganyi MC, Tlatsana GS, Mokoroane GT, Senna KP, Mohaswa JF, Ntsayagae K, Fri J, Ateba CN. 2021. Bulbous plants *Drimia*: a thin line between poisonous and healing compounds with biological activities. Pharmaceutics 13(9): 1385. doi: 10.3390/pharmaceutics13091385

Martin E. 2006. Survey questionnaire construction. Survey Methodology 13: 1-13.

Medail F, Quezel P. 1997. Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Annals of the Missouri Botanical Garden 84: 112-127.

Merad R. 1997. Scilla maritima L. Baker (PIM 479F, French). International Programme on Chemical Safety. https://www.inchem.org/

Merrouni IA, Kharchoufa L, Bencheikh N, Elachouri M. 2021. Ethnobotanical profile of medicinal plants used by people of North-eastern Morocco: cross-cultural and historical approach (Part I). Ethnobotany Research and Applications 21: 1-45. doi: 10.32859/era.21.13.1-45

Mirari S. 2018. The sustainable development of Oued Noun Oases through the integration in the Biosphere Reserve Oasis of Southern Morocco. [Master's thesis, Université Ibn Zohr, Agadir, Morocco].

Mokhtari N, Mrabet R, Lebailly P, Bock L. 2014. Spatialization of bioclimates, aridity and vegetation stages of Morocco. Revue Marocaine des Sciences Agronomiques et Veterinaires 2(1): 50-66.

Msanda F, Mayad EH, Furze JN. 2021. Floristic biodiversity, biogeographical significance, and importance of Morocco's Arganeraie Biosphere Reserve. Environmental Science and Pollution Research 28(45): 64156-64165. doi: 10.1007/s11356-021-14951-1

Nieto G. 2017. Biological activities of three essential oils of the Lamiaceae family. Medicines 4(3): 63. doi: 10.3390/medicines4030063

Okpashi VE, Oyo-Ita EEA, Jones BB, Obeten UN, Ucho KM, Ofoelo LI. 2021. Identification and characterization of bioactive components in *Datura stramonium* leaves: an insight into drugs discovery. Journal of Applied Sciences and Environmental Management 25(10): 1789-1799. doi: 10.4314/jasem.v25i10.7

Petrova M, Dimitrova L, Dimitrova M, Denev P, Teneva D, Georgieva A, Petkova-Kirova P, Lazarova M, Tasheva K. 2023. Antitumor and antioxidant activities of in vitro cultivated and wild-growing *Clinopodium vulgare* L. plants. Plants 12(8): 1591. doi: 10.3390/plants12081591

Plan HC. 2019. Monographie de la province d'Errachidia. In: 2019 ed. Haut Commissariat au Plan, Rabat, Morocco.

Salem ABE, El Filali AEA. 2024. Addressing climate change and building resilience in the Draa-Tafilalet Region. In: International Conference on Advanced Intelligent Systems for Sustainable Development (AI2SD'2023): Advanced Intelligent Systems on Energy, Environment and Agriculture, Volume 1. Springer, Cham, Switzerland.

Sayed-Ahmad B, Talou T, Saad Z, Hijazi A, Merah O. 2017. The Apiaceae: ethnomedicinal family as source for industrial uses. Industrial Crops and Products 109: 661-671. doi: 10.1016/j.indcrop.2017.09.027

Senouci F, Ababou A, Chouieb M, Chouieb M. 2019. Ethnobotanical survey of the medicinal plants used in the southern Mediterranean. Case study: the region of Bissa (Northeastern Dahra Mountains, Algeria). Pharmacognosy Journal 11(4): 647-659. doi: 10.5530/pj.2019.11.103

Shaghaghi A, Alirezalu A, Nazarianpour E, Sonboli A, Nejad-Ebrahimi S. 2019. Opioid alkaloids profiling and antioxidant capacity of *Papaver* species from Iran. Industrial Crops and Products 142: 111870. doi: 10.1016/j.indcrop.2019.111870

Sharma M, Dhaliwal I, Rana K, Delta AK, Kaushik P. 2021. Phytochemistry, pharmacology, and toxicology of *Datura* species: a review. Antioxidants 10(8): 1291. doi: 10.3390/antiox10081291

Shi G, Ni L, Zhang Y, Qu Z, Kong X, Zhou H, Xu Y. 2025. Ethnobotany, phytochemistry, pharmacology and toxicity of *Hagenia abyssinica* (Bruce) J.F.Gmel.: a review. Frontiers in Pharmacology 16: 1593724. doi: 10.3389/fphar.2025.1593724

Shreya R, Sharma B, Alam A, Sharma S. 2023. Ethnomedicinal importance of Fabaceae family (Angiosperms) among the tribes of Rajasthan, India. Natural Resources for Human Health 3(2): 237-247. doi: 10.53365/nrfhh/158809

Shridhar NB. 2022. Nerium oleander toxicity: a review. International Journal of Advanced Academic Studies 4(3): 23-32. doi: 10.33545/27068919.2022.v4.i3a.813

South African National Biodiversity Institute, JBdG, Tela Botanica, Missouri Botanical Garden.. 2026. World Flora Online. https://www.worldfloraonline.org/

Tlemcani S, Lahkimi A, Eloutassi N, Bendaoud A, Hmamou A, Bekkari H. 2023. Ethnobotanical study of medicinal plants in the Fez-Meknes region of Morocco. Journal of Pharmacy & Pharmacognosy Research 11(1): 137-159. doi: 10.56499/jppres22.1459_11.1.137

Uikey DJ. 2024. Reviewing of plant belonging to Lamiaceae family. International Journal of Advanced Research in Botany 9(3): 1-10.

Ullah R, Alqahtani AS, Noman OMA, Alqahtani AM, Ibenmoussa S, Bourhia M. 2020. A review on ethno-medicinal plants used in traditional medicine in the Kingdom of Saudi Arabia. Saudi Journal of Biological Sciences 27(10): 2706-2718. doi: 10.1016/j.sjbs.2020.06.020

Umukoro S, Ashorobi RB. 2007. Further studies on the antinociceptive action of aqueous seed extract of *Aframomum melegueta*. Journal of Ethnopharmacology 109(3): 501-504. doi: 10.1016/j.jep.2006.08.025

UNESCO, 2000 Oasis du Sud du Maroc.Visited 4 avril 2026 from https://www.unesco.org/en/mab/oasis-du-sud-marocain

Valdés B, Rejdali M, Achhal El kadmiri A, Jury JL, Montserrat JM. 2002. Catalogue des plantes vasculaires du Nord du Maroc incluant des clés d'identification. Consejo Superior de Investigaciones Científicas.

Yang J, Li Y, He Y, He H, Chen X, Liu T, Zhu B. 2023. Wild vs. cultivated *Zingiber striolatum* Diels: nutritional and biological activity differences. Plants 12(11): 2180. doi: 10.3390/plants12112180

Youssef EA, El-Assri EM, Mahraz MA, Mounadi Idrissi A, Moussaoui F, Khabchi M, Boukour S, Eloutassi N, Laglaoui A, Lahkimi A. 2025. Ethnobotanical and ethnopharmacological studies of medicinal plants in the southern Mediterranean: Tangier-Tetouan region, Northern Morocco. Tropical Journal of Natural Product Research 9: 1039-1057. doi: 10.26538/tjnpr/v9i3.20